VOLUME 14 • NUMBER 2 • AUGUST, 1941

Metals and Alloys

Published Monthly by Reinhold Publishing Corporation, East Stroudsburg, Pa., U.S.A. Ralph Reinhold, President and Treasurer; H. Burton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President. Executive and Editorial Offices, 330 West 42nd Street, New York. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft.) Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

Articles

Metallurgical Engineering Digest

THIS YOUTH CAN HELP YOU MEET YOUR TOOL MAKING PROBLEM!

PROVIDED you can tap his reservoir of native ability, by giving him *quickly* the sound foundation of training in tool making fundamentals and techniques he needs. Eager to help — he waits only the chance you can give him to serve you and his country.

Have you started—are you planning to start—the apprentice training course that will release his young energies and enthusiasms in the building of his own and industry's future?

If so, what and how much will he learn about the proper selection and heat treatment of tool steels, on which lies so much of the responsibility for the success or failure of tools?

Out of the laboratories, up from the tool room, straight from the hardening furnaces, has come a book to give him the hard kernel of "Know-How" which you yourself would implant could you but shepherd his course.

This book, "Tool Steel Simplified"—so timely, so easy-to-read, so practical, that it is already in its seventh reprinting—was developed in cooperation with many of America's leading tool rooms. Thousands of skilled, experienced tool makers use it daily to help solve their problems of tool steel selection and heat treatment. And yet "Tool Steel Simplified" is so understandable, so theoretically sound that additional thousands of copies have been purchased for vocational training purposes. Altogether, more than 20,000 copies are in use.

If you are concerned with this problem of training tool makers and tool hardeners, accept this invitation. Get a copy yourself. Read it. See how, see where, it can help further your program.

The cost? Only $1.00 in the U.S.A.—though the book is 316 pages, of standard textbook size, quality and binding, with 203 illustrations—some in full color. Its cost is purposely low—so that it can be made more freely available to all who may need it.

To get your copy of "Tool Steel Simplified", send us your order with $1.00—or use the coupon below. You'll find a way to give that boy, who wants to help, a welcome boost, at a time when his services will be invaluable to your company and the nation.

The Standard Tool Steels of Industry

THE CARPENTER STEEL COMPANY
READING, PA.

Carpenter MATCHED TOOL STEELS

BRANCH WAREHOUSES AT—Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, Philadelphia.

Feature Section

Die or Permanent Mold Castings

Our leading article is of direct interest to design engineers who contemplate the use of either die castings or permanent mold castings. Comparisons are made of both types of product by Mr. Chase. The concluding portion is scheduled for September.

Hardening by Precipitation

Actually the common, everyday steels appear subject to the precipitation-hardening type of phenomena, although this has generally been thought of in relation to non-ferrous alloys or to some complex and highly alloyed ferrous alloys. This correlated abstract reviews the field completely.

Air-Hardened Tool Steel

A heat-treating article of interest is our third contribution. It deals with distortion or size change which takes place in the air-hardening type of high-carbon, high-chromium tool steels.

Indium as an Alloy

Some late facts about the alloying possibilities and effects of the rather rare metal, indium, are found in the article by Dr. Fraenkel. Special reference is to age-hardenable aluminum alloys.

Container for Radium

In the non-destructive testing of metals, radium is an important factor. And the handling of it is often a difficult problem. The article by Mr. Kaiser describes an ingenious device for a metal shipping container for radium in connection with its various uses in industry and medicine. It is said to be as satisfactory as well as cheaper than one of a tungsten-nickel-copper alloy.

Creep Properties of a High Alloy Steel

The creep properties of certain heat-resisting steels are very important in certain industries. Mr. Newell discusses the creep properties of a 16 Cr-13 Ni-3 per cent Mo steel in the last article in this issue.

Engineering Digests

Hydrogen Again

Modern non-ferrous alloys are no exception to the general metallurgical abhorrence of that arch-villain—hydrogen. Kelly (page 210) claims it is the source of embrittling effects in copper, and recommends melting in an oxidizing atmosphere followed by deoxidation with calcium boride.

Plating Metals on Non-Metals

Methods of coating non-metals with metals ("Electroplasty" to them as knows) are described by Bregman (page 216).

Is Induction Hardening "Different"?

Osborn (page 218) says surface hardening of steels by high-frequency induction gives metallurgical structure and properties that are different from those obtained by conventional treatments.

Electropolishing of Nickel-Plate

Anodic polishing of dull nickel electroplates gives a surface as lustrous as that obtained by mechanical polishing of nickel coating, report Hothersall & Hammond (page 228).

Metal-Design of Aircraft Engines

Materials and manufacturing processes used for several American airplane engines are discussed and tabulated in a "composite" on page 232.

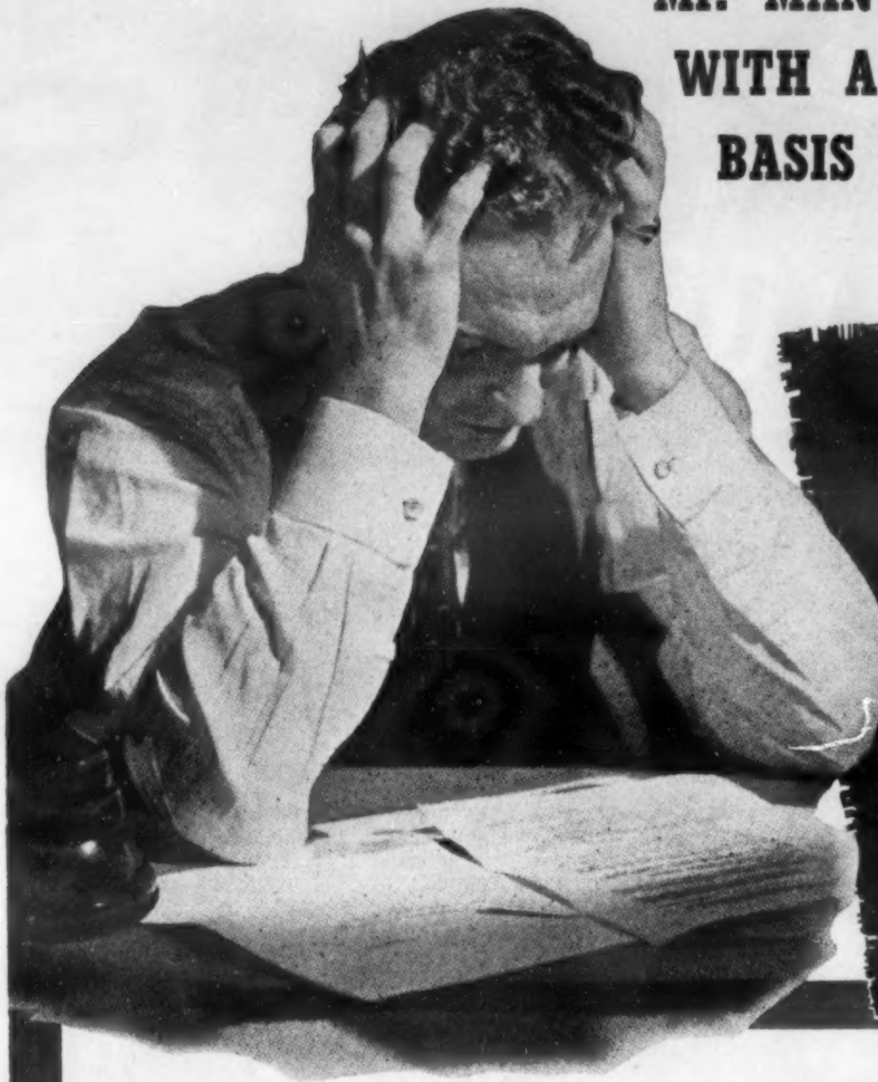
Plastics Make Hay

We know that, through chemurgy, actually the reverse of the above statement is true, but right now we refer to all the useful little products that engineers have had to redesign for plastics in the "temporary" absence of their pet metals—as reviewed broadly in a "composite" on page 238.

Bismuth Improves Stainless Steel

Bismuth additions to stainless steel make it free-machining without detriment to other properties, report Pray, Peoples & Fink (page 241).

Mr. MANUFACTURER, ARE YOU FACED WITH A PROBLEM of HOW TO CLEAN BASIS METALS for DEFENSE ORDERS?



LET A QUALIFIED ENGINEER SHOW YOU HOW OTHERS ARE MEETING THIS IMMEDIATE PROBLEM

MacDermid Has An Approved Chemical and Process for the Cleaning of Basis Metals Needed for Defense

FOR 22 YEARS MacDermid, Inc. has specialized in perfecting formulae and processes for the cleansing of basis metals. Many of these proven procedures were immediately adaptable for use by ammunition manufacturers, airplane manufacturers, and other industries filling defense orders. For the past few years special formulae and processes have been developed by MacDermid's chemists to meet every immediate need and, as the occasion arises, new ones will be added to this list. For example, MacDermid offers . . .

The *approved methods* and *compound* for cleaning brass cartridge cases of all calibers.

An *accepted procedure* for cleaning aluminum and aluminum alloys prior to anodizing.

ANODEX for producing chemically and metallurgically clean surfaces prior to electroplating.

SOLVTEX and *special compounds* for washing machines.

MANUFACTURED SOLELY BY

MACDERMID

INCORPORATED

WATERBURY • CONNECTICUT

SALES AND SERVICE

New York . . . Cleveland . . .
Los Angeles . . . Dayton . . .
Newark . . . Detroit . . . St. Louis
Philadelphia . . . Toronto, Can.

editorial

That Expanding Horizon

We quote from an article in *Science,* Friday, June 13, 1941 (not April 1): "The use of beryllium metal, which is remarkably hard and elastic, as armor plate for aircraft, has been so satisfactory that beryllium has been mentioned among the critical materials of modern warfare."

This was stated by a professor in a talk before a chapter of Sigma Xi on "The Expanding Horizon of Inorganic Chemistry."

It should rightfully go under "Chuckles," but in view of the way misinformation quotes and requotes itself, especially in text books written by college professors from the publications of other college professors, it is too serious a symptom to be put under that heading.

A query to any metallurgical engineer or aeronautic expert would have saved the professor of chemistry from going off the deep end, or from failing to realize that somebody was kidding him.

Perhaps enough metallic beryllium as "plate" has been produced to armor one toy airplane model against a BB gun, though it is said that a gun was once fired against one chunk of Be. Projection from this to "use" and to "modern warfare" is pretty much in line with some of the Sunday paper discussions of beryllium, but it is a shock to find it in *Science,* even on Friday the thirteenth.—H.W.G.

Everything for Defense

Everything is for defense these days. We note that a preparation for neutralizing or preventing under-arm odor is advertised for lieutenants so their partners will not be offended when dancing with them. Thus we judge that manufacture of such preparations should carry high priority, and for the workmen in the industry freedom from the draft.

This is business-as-usual to the nth degree, but it isn't much worse than a lot of the other business-as-usual attitudes.—H. W. G.

Our Real Steel Capacity

Early this year the American Iron and Steel Institute published its estimate of the steel capacity of the United States as 84,152,000 net tons as of Dec. 31, 1940. This represents ingots and such steel castings as are made by ingot producing companies.

This estimate does not represent the entire industry. While the output of our steel foundries is not large, it is important. We are informed by the Steel Founders' Society of America that its capacity is estimated at 1,320,000 annually. Adding this to the other estimate, the total steel capacity is not less than 85,472,000 tons.

As of Dec. 31, 1940, the Institute estimates our electric furnace steel capacity as 2,586,000 tons per year. The steel foundry industry is a large producer of important castings in electric furnaces. The same authority quoted above estimates the electric steel casting capacity as 420,000 tons each year. The combined capacity for electric steel is therefore over 3,000,000 tons.

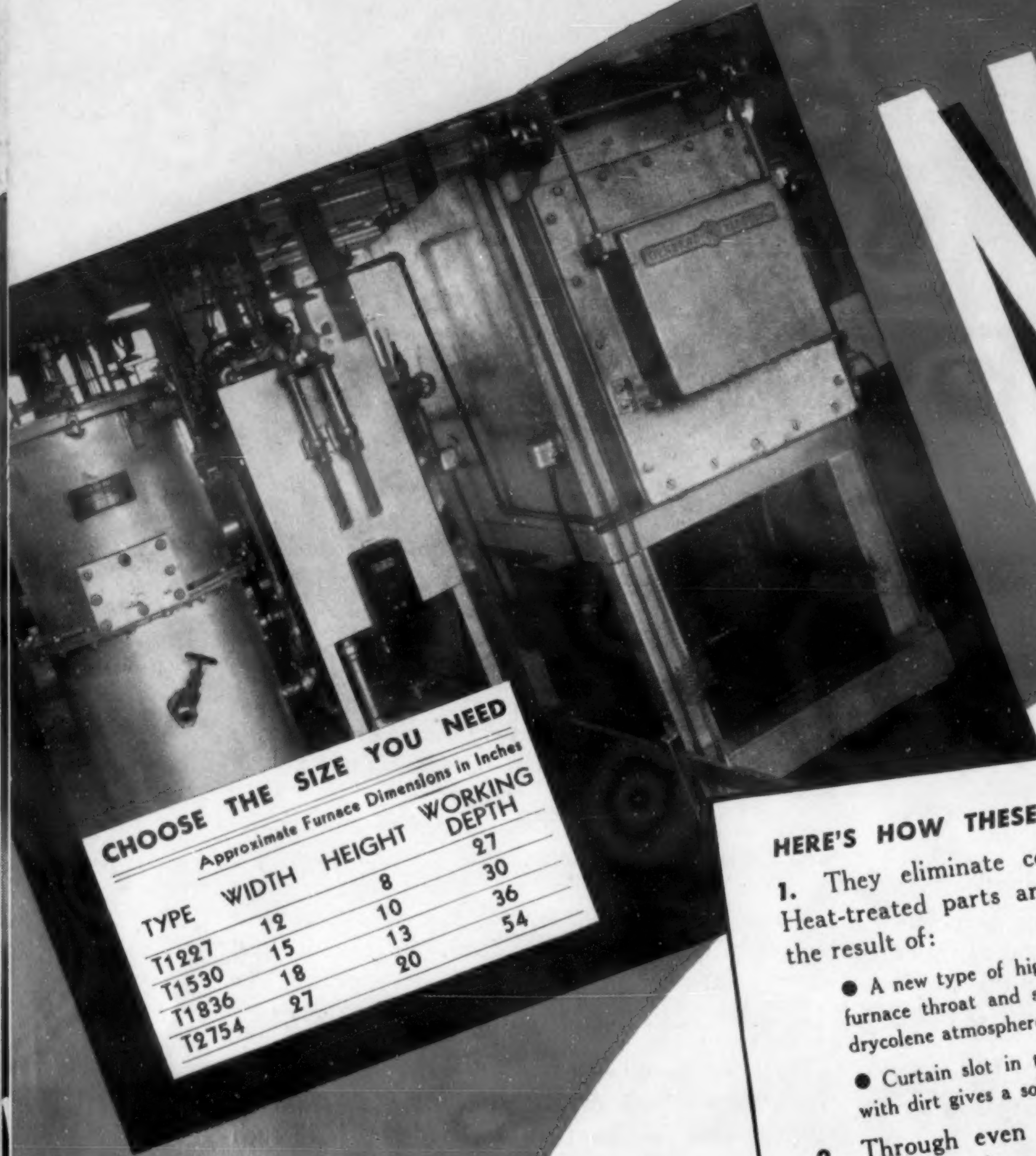
Both of these estimates are record figures and from present indications they will be exceeded in 1941. That the American steel industry is in such splendid condition to meet present needs after 10 lean years, is signal testimony to the foresight and good judgment of its leaders.—E. F. C.

Since the above was written, the suggestion (or command?) has come from Washington that the capacity be augmented by 10,000,000 tons! The steel industry as a whole regards this as fantastic especially when it is reliably estimated that, to attain this, over 4,000,000 tons of steel and $1,250,000,000 of good American money will be necessary. It seems evident that it is unwise to divert 4,000,000 tons of steel from Defense needs to new capacity.

Already (July) it is certain that our ingot and casting capacity has been augmented by natural evolutionary developments from the 85,472,000 tons referred to above to close to 90,000,000 tons. This has come about by speeding up blast furnace, open-hearth and electric furnace practice and by necessary gradual enlargements of capacity. At the same time there are other factors such as duplexing the cupola with the open-hearth, enlarged Bessemer converters, and the return of the converter in the steel foundry

(Continued on page 182)

NOW



CHOOSE THE SIZE YOU NEED

Approximate Furnace Dimensions in Inches

TYPE	WIDTH	HEIGHT	WORKING DEPTH
T1227	12	8	27
T1530	15	10	30
T1836	18	13	36
T2754	27	20	54

HERE'S HOW THESE NEW FURNACES SAVE FOR YOU

1. They eliminate costly cleaning and machine operations. Heat-treated parts are scale and decarburization free. This is the result of:

- A new type of high-velocity flame curtain projects downward into the furnace throat and seals the furnace against entrance of air and loss of drycolene atmosphere when door is opened.
- Curtain slot in top of furnace throat where it cannot become clogged with dirt gives a solid, unbroken flame curtain.

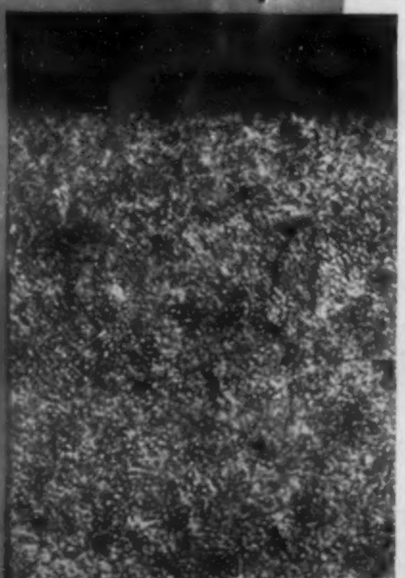
2. Through even heat distribution and accurate temperature control, the furnaces produce parts of uniformly hardened material. This is the result of:.

- Carefully proportioned heating resistors are divided into two circuits—one automatically controlled and one to compensate for end losses.

3. Ease of operation, ease of maintenance, cleanliness, and low heat losses increase production speed.

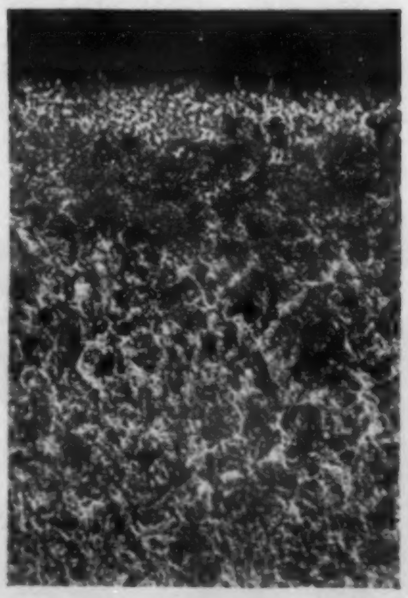
PROOF THAT DRYCOLENE PREVENTS DECARB

Compare Photos 1 and 2 **Compare Photos 3 and 4**



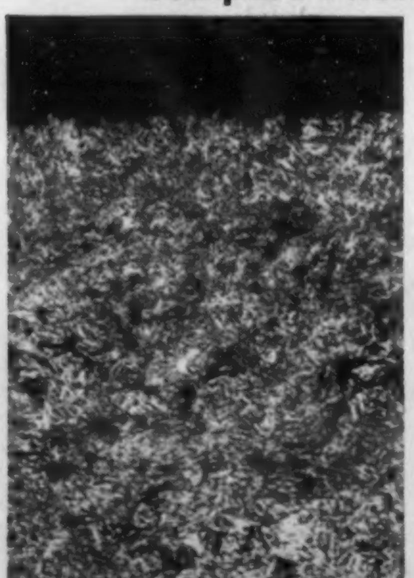
No. 1

SAE 52100 after 2 hours, 1500 F, in furnace using drycolene as a protective atmosphere. Absolute uniformity of structure extending to surface is proof of no decarbu-



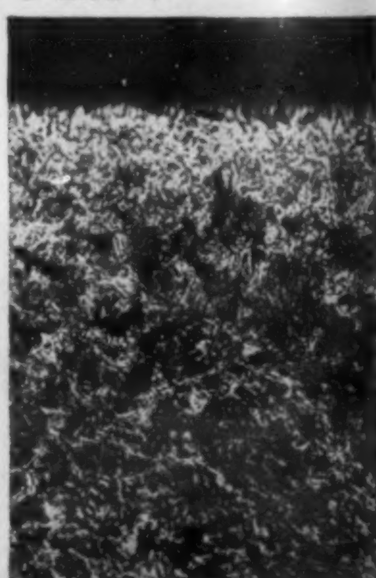
No. 2

SAE 52100 after 2 hours, 1500 F, in furnace using partially converted gas as protective atmosphere. The white band at the surface indicates carbon-free ferrite



No. 3

SAE 1090 after 2 hours, 1500 F, in furnace using drycolene atmosphere. Structure is uniform — not a trace of decarburization.



No. 4

SAE 1090 after 2 hours, 1500 F, in furnace using partially converted gas as protective atmosphere. The depth of the white, ferrite-rich band indicates decarburization.

A BOX-TYPE FURNACE *for* NO DECARB

Prevents Decarburization when Used with Drycolene Protective Atmosphere, Assuring Scale-free Surfaces of Heat-treated Steels

RECENTLY General Electric announced a new protective atmosphere—drycolene, an atmosphere-gas that prevents decarburizing in the heat treatment of carbon and alloy steels. Now, we give you a complete line of new box-type tool-room furnaces designed for use with drycolene. For no decarburization and no scale, this combination of furnace and drycolene producer is ideal. It is easy to operate, and made in four sizes to meet various requirements.

Why Drycolene Prevents Decarb

Drycolene is a balanced blend of gases, containing no oxygen, moisture, or carbon dioxide—the decarburizing agents. Hence, no decarburizing reaction can take place between the atmosphere and the steel.

Let us eliminate decarburization in that difficult hardening job and assure you hardness uniformity. G-E engineers can recommend the right furnace. Get in touch with our nearest office. General Electric Company, Schenectady, N. Y.

WEIGHT CHANGE AND HARDNESS COMPARISONS PROVE ABSENCE OF DECARBURIZATION

Comparison of Identical Steels Treated in Drycolene and Ordinary Combusted Gas

Photomicrograph (on the opposite page)	Steel SAE No.	Hardened at	Hours in Furnace	Treated in	Weight Change G Per Sq CmX100,000	Rockwell "C" Scale	Hardness *15N Scale
No. 1	52100	1500	2	drycolene	+19	66.8	68.6
No. 2	52100	1500	2	combusted gas	−45	62.5	60.0
No. 3	1090	1500	2	drycolene	+2	66.5	66.8
No. 4	1090	1500	2	combusted gas	−44	63.0	61.0

*Readings are 15N superficial hardness converted to "C" readings for comparison with "C" readings taken directly. Readings taken in the "as quenched" condition.
1 and 3—Very slight carburization is indicated by both an increase in weight and a superficial hardness greater than the "C" hardness. Carburization is so slight that it does not show in photomicrographs.
2 and 4—Decarburization is proved by loss in weight and a superficial hardness lower than the "C" scale reading. Decarburization shows plainly in photomicrographs.

GENERAL ELECTRIC

PART 1

Permanent Mold and Die Castings Compared

by HERBERT CHASE

For those contemplating the use of either die castings or permanent mold castings in certain engineering designs, this article gives comprehensive comparative data on the two types of products. The author discusses the choice of the alloy suitable for either permanent mold or die castings, the relative cost of dies, the over-all, and finishing costs. Comparative production rates are reviewed. Many other phases of the subject such as section thickness, porosity, dimensional accuracy, and relative strength are also discussed.—The Editors.

When making a choice as between permanent mold castings and die castings, a great many factors have to be considered and any one of them may have a controlling effect upon which is selected. Much the same may be said as to the choice between any two types of metal products which can be used alternatively, but the factors which control the choice as between die castings and permanent mold castings naturally differ to some extent from those involved in comparing other types of product.

Permanent mold castings, as here considered, are of the type made in "permanent" metal molds usually produced from alloy cast iron, the metal being ladled into the mold under a gravity head and without the application of other pressure. In England, such castings are sometimes referred to as "die castings," as distinct from "pressure die castings" but in this country the term "die casting" is reserved for the type produced under pressure in machines termed "die casting machines."

The pressures applied commonly range from about 400 lb. per sq. in. upward to several thousand. In most cases, no ladling of metal is involved, but in the "cold chamber" type of die casting machine, which is gaining in use for aluminum, magnesium and copper-base alloys, the molten metal is ladled into the machine by hand and then immediately subjected to very high positive pressures by a plunger which forces it into the die. The products of such machines are sometimes referred to as "pressure castings," but they are, of course, a form of die casting.

So called "semi-permanent mold" castings are considered here as one form of the permanent mold type, as the molds themselves are of the same character. In such castings, however, sand cores are employed and, as a new core is required for each casting, a portion of the mold, that is, the core, is not permanent, hence the term "semi-permanent" is applied to the casting assembly as a whole and the product it turns out. Except for the core and its separate production, the process of making "semi-permanent mold" castings is the same as that for the permanent mold type. But, as the core is of sand, it has the characteristics of sand cores and is subject to their dimensional limitations or inaccuracies. The use of sand cores, however, is commonly limited to castings involving undercuts or to some shape which is not commercially feasible to produce or to withdraw from the casting if the core were made from metal. Many cores made from metal also are used in making permanent mold castings. Although

Pouring a typical small size permanent mold aluminum alloy casting, the metal being ladled from the melting pot in the background. In this case, the mold is split vertically and hinged about the pin in the foreground. It is held together by the clamp at the left and, when the casting has solidified, is swung open to permit ejection of the casting.

their application involves certain limitations not always applying to the die casting, their utility is considerable. They are used much more often than sand cores and the permanent mold casting is more widely employed than the semi-permanent mold type.

Although many permanent mold castings having a ferrous base are produced, attention here is confined to the non-ferrous type, both for simplicity's sake and because the comparison is with non-ferrous die castings. Also omitted from this discussion are "slush" castings (a special form of permanent mold castings), since the inclusion of this form would complicate the comparison.

Choice of Alloy

Among the basic and highly important considerations entering into a choice between permanent mold and die castings is, naturally, that of the alloy to be used. In die castings, the modern zinc alloys are used for about three-fourths of the total output because they cast so readily with relatively close dimensional tolerances, have excellent physical and mechanical properties, are low in cost, yield a remarkably smooth surface and are readily adapted to plating. But the zinc alloys for die castings are not well suited for use in permanent molds and those zinc alloys which are suited, as far as casting is concerned, are greatly inferior in strength to those so justly popular in die casting.

Aluminum alloys rank first in importance in permanent mold casting but are second to the zinc alloys in extent of use in die casting. Certain of the aluminum alloys can be used either for die casting or for permanent mold casting. Some, in the latter forms, (unless subsequently heat-treated), have, in test bars, a somewhat lower tensile strength than when die cast. In practice, however, this difference may be offset by porosity in the die casting which, in the permanent mold type, is less in degree. Certain of the aluminum alloys suited for permanent mold work can be heat-treated with improvement in physical properties and the maximum tensile strength attained by these alloys in their heat-treated form is greater than that in any of the standard aluminum die casting alloys.

Although certain aluminum alloys which could be die cast might have their physical properties improved by a heat treatment similar to that applied to permanent mold aluminum alloys, such treatment is not usually feasible because blistering is likely to result. It is doubtful if porosity can be eliminated either in die castings (even in those made in "cold chamber" machines) or in permanent mold castings, but one maker of both types (in aluminum alloys), states that, to date, the permanent mold type has consistently the better physical properties. Reference to the accompanying table will show the relative properties insofar as comparative figures have been made available by those who produce the respective types of castings. If properties other than tensile strength be compared, as for impact strength, for example, the order of merit naturally will vary.

Secondary aluminum (quotations on secondary aluminum are under some special conditions higher than for virgin aluminum which is the reverse of the usual conditions to which the statements here apply) is widely used in preparing alloys for both permanent mold and die casting purposes, but according to one maker of permanent mold castings, a cheaper grade can often be used for the permanent mold type. If virgin metals be used, material costs are about on a par, since compositions are similar, but when, as in some cases, the die casting can be made in thinner sections and still serve the same purpose, this saves somewhat in metal costs. In both types of castings, scrap losses are low, as gates, flash and rejects are remelted with only minor losses in metal.

Some copper base alloys are successfully cast in permanent molds and rank next to aluminum in commercial importance in this field, just as they do in die casting, although in the former the two are first and second, in extent of use, whereas, in die casting, they rank second and third, respectively. Magnesium alloys are gaining rapidly in die casting, especially where minimum weight is desired, but are only a minor factor as yet in the permanent mold field, although some permanent mold magnesium castings have been produced and plans for their production in large quantities are reported under consideration.

Several of the producers of permanent mold castings also have departments in which die castings are turned out. There is some degree of competition between the two types of castings, but it is chiefly between castings in alloys of the same base metal. Thus, die castings in aluminum alloy are chiefly competitive with permanent mold castings in the same or some similar alloy based on aluminum. There is considerable competition between the zinc alloy castings on the one hand and aluminum alloy permanent mold castings on the other, especially where quantities are small, as, in such cases, the lower cost of the permanent mold may outweigh the lower production rate of the latter. A few types of parts have been made in both forms, but some one or more factors, including cost considerations, are likely to dictate the use of one or the other form of casting for reasons now to be outlined.

Die Cost

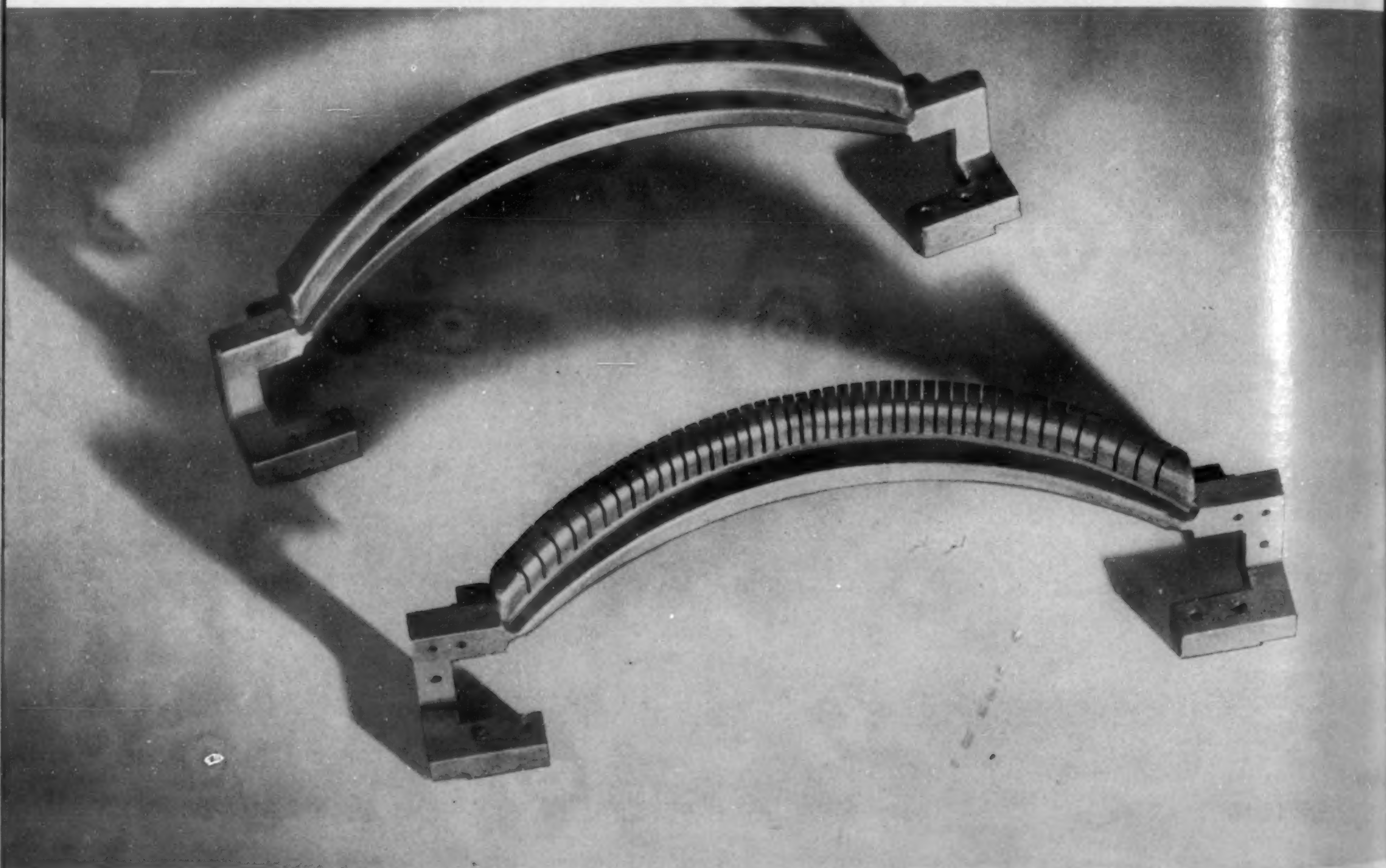
Dies for producing die castings are commonly made from steel. The cavities are cut or hobbed from the solid metal, and, except for zinc alloys (and even sometimes for them) and those of lower melting point, the dies require hardening to secure ade-

quate die life. After hardening, the cavities are usually highly polished, especially where a corresponding polish is required on the castings. The cost of making these dies is lower than it once was, because of improved tools and machining methods, but often represents a large investment to be charged off (for good economy) or prorated over the total number of castings known to be required. Often multiple cavities (which may be duplicates or all different) are used with added economy. The dies are always used in a machine adapted for rapid opening and closing them and for securely locking the dies when the metal is injected.

As against this, the permanent mold is usually cast (perhaps except for cores, which may be of wrought metal) in alloy iron having good heat resisting qualities. The cavity or cavities are commonly cast also, but with due allowance for accurate machining, as well as for a wash or "paint" of refractory material which is applied before castings are made and usually daily thereafter, when the die is in use. This wash helps to protect the metal against checking and erosion and, although affording a smooth surface, is never so smooth as a well polished surface of a die casting die. Consequently the die does not produce castings quite so smooth as good die castings, although permanent mold castings are much better in respect to surface smoothness than sand castings.

Permanent molds cost less than equivalent die casting dies, in the average case, perhaps one-third to one-half as much. Upkeep cost as between dies and

Typewriter part which has been produced as a die casting (as shown in unmachined form) and also as a permanent mold casting (as shown with slots and some other machining done). Both parts are in aluminum alloy. It was anticipated that the die casting would result in considerable saving, especially in machine work, but it developed that the slots could not be cored, that only 4 of 18 holes could be cored and that some flat surfaces, which had to be machined on the permanent mold casting also had to be cleaned off in the die casting. As a result, the saving on the latter amounted to only 3.50 per cent. Both types of castings are being continued so as to have two sources of supply.



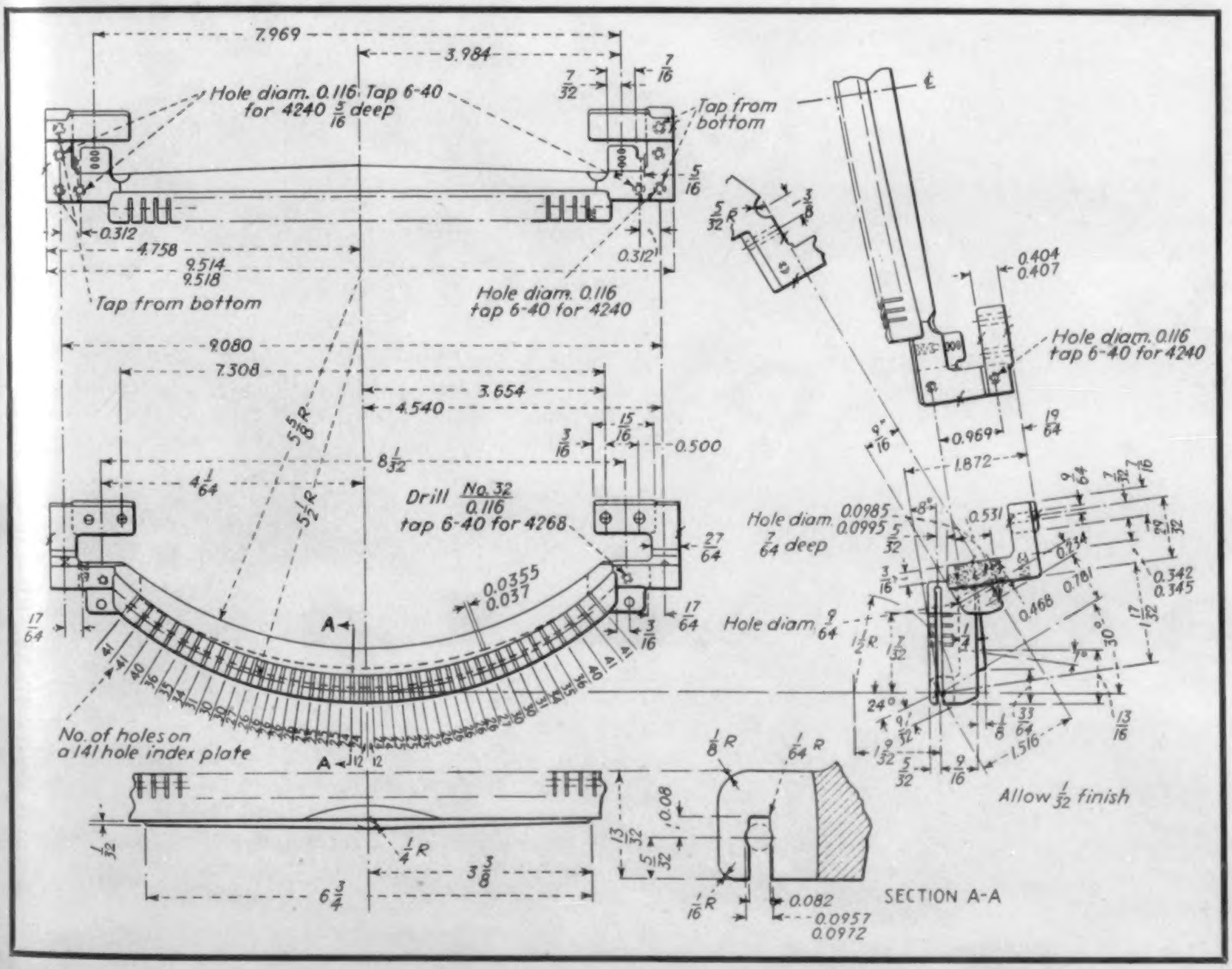
molds is reported to be about on a par and die and mold life is said to be about equal when both die and mold are used for casting the same type of metal. The higher the melting point of the alloy to be cast, the higher is die or mold upkeep and the shorter, the life of each. This may be of importance if the choice is, for example, between a die casting in zinc alloy (which has a low melting point and for which dies last almost indefinitely) and a permanent mold casting in aluminum or in copper base alloy.

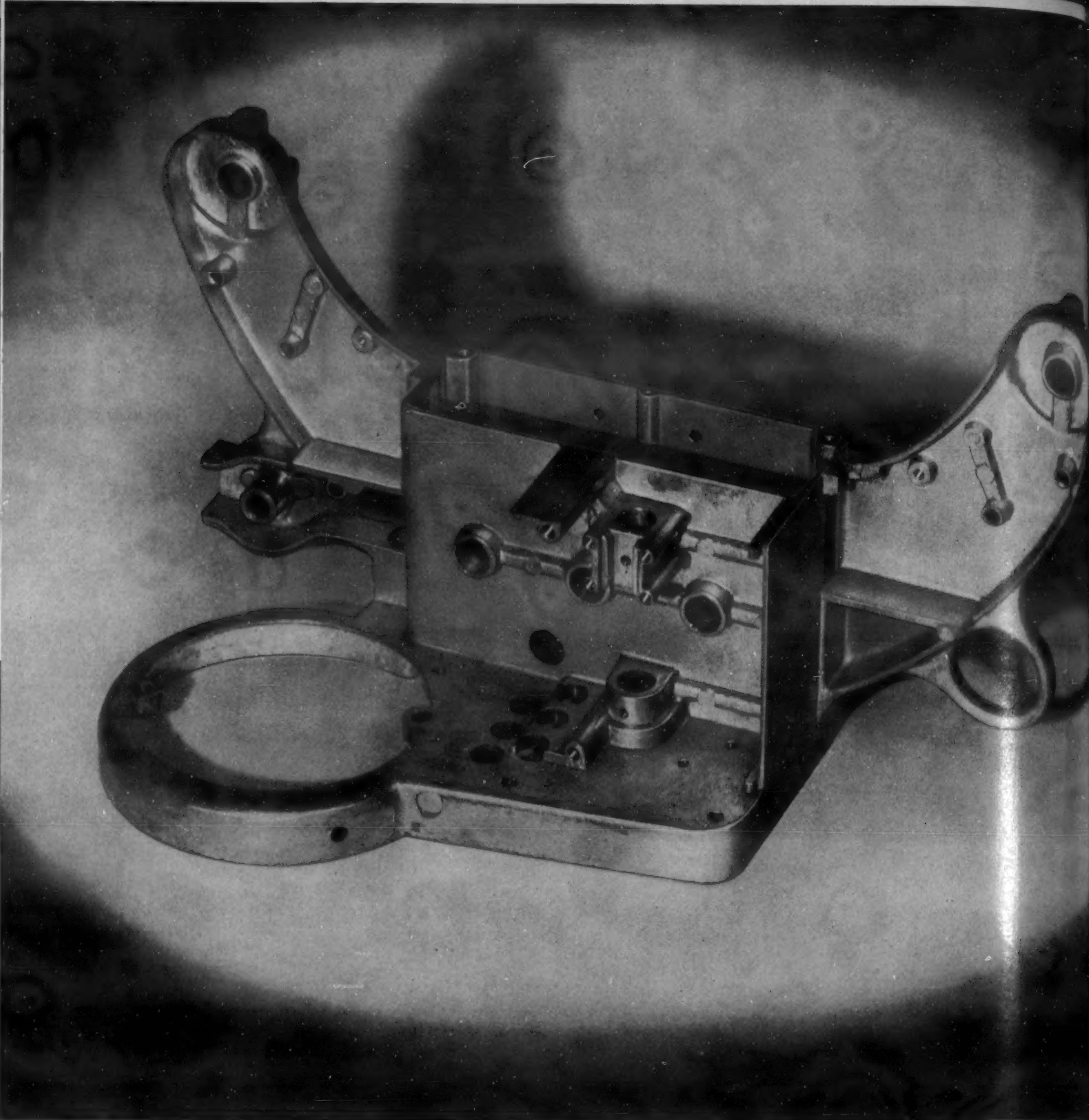
Over-all Cost

Many factors beside die cost have a bearing on overall cost, among them being the cost of the metal, the rate of production, upkeep cost on dies or molds and machines, relative ease and amount of machining required, minimum section thickness feasible, and the cost of an applied finish when one is necessary. The lower cost of molds as against dies sometimes favors the permanent mold casting, especially when quantities are small, but if they be large or if other factors favor the die casting, as they often do, over-all cost may favor the die casting. Only when all factors involved are weighed can over-all cost be determined, hence any generalization in this regard requires too many qualifications to be of much value.

In favor of the permanent mold casting is the lower cost of the machine (when it can be termed such) in which it is produced. Since the pressures applied are low, (gravity head only) relatively low locking pressures are required and often the die parts are merely hinged together and only hand clamps are needed. The die may even be used on a metal table or support which is hardly to be classed as a "machine." In other cases, especially for large molds, hydraulic or pneumatic sliding and/

Drawing of the same permanent mold casting shown in the first illustration but indicating the dimensional limits which must be held in the finished piece. Finish marks show the flat surfaces which require machining. The same drawing is used for machining slots, drilling holes not cored to size and doing such other machining as is needed in the die casting.





Part for a motion picture projector, typical of many complex die castings in zinc alloy with thinner sections and much more complex coring than are commonly attempted in making permanent mold castings, regardless of alloy employed.

or locking parts are needed or are justified by the greater speed of operation. These and related parts involve more of a machine, though one lower in cost than for most die casting work. Cores are often placed and operated by hand, but sometimes mechanically operated cores and push-outs are needed, much as for die casting.

For the semi-permanent mold type of casting, tooling cost is augmented by the cost of core-making equipment, including the core boxes required, but

such cores are avoided unless essential and, when they are required, afford a means for making cores giving internal shapes not feasible in die casting.

Production Rates

Partly because of the more highly developed machines used for die casting, the rate of production of die castings generally is much greater than for permanent mold castings. This applies especially to machines equipped for mechanical injection of zinc alloy, but may apply also to air injection machines and to cold chamber machines for making aluminum alloy die castings. In cold chamber machines, the charge is ladled, much as it is in making permanent mold castings. Thus, an injection type of die casting machine for zinc alloy makes from 60 up to as many as 1000 or more shots (die fillings) per hour. The low figure applies to only a few very large die castings, the average probably being 200 to 300 shots an hour; 400 to 500 shots are quite often attained. In aluminum alloy die casting, rates range

Group of permanent mold and semi-permanent mold castings typical of those produced in aluminum alloys. Some similar parts have been die cast, usually also in aluminum alloy, chiefly to gain light weight or special forms of corrosion resistance, but the cylinder head and two of the larger parts to the left of it (among others) require sand cores, (putting them in the semi-permanent mold classification) and cannot be die cast.

from about 40 up to about 110 shots an hour or possibly slightly higher. As against this, the production of permanent mold castings does not often exceed 75 die fillings an hour, with 50 large castings an hour per machine unusually good. One maker considers 25 washing machine agitators an hour as a good rate. Another says that 50 an hour is a top figure and a third says 550 a day can be turned out by an operator who runs two molds simultaneously. Automobile pistons, which are large quantity items, though requiring special metal core work, are made at about 45 to 65 an hour (perhaps slightly faster under some conditions) in permanent molds. One maker reports 1000 small permanent mold castings in aluminum alloy per 8-hr. day, or as many as 800 per mold per day. The use of sand cores slows the casting cycle, besides requiring much labor in producing the cores. Without question, the die casting cycle averages much shorter than that for permanent mold castings, even for castings of the same size and weight.

One of the two direct comparisons the author has been able to secure concerns a vacuum cleaner fan case which was first produced in a semi-permanent mold, using an aluminum alloy, at the rate of 60 castings an hour. This casting weighed 1.48 lbs. Later, a similar casting for the same purpose was made in a cold-chamber die casting machine at the rate of 100 an hour, which, presumably, allows for inserting in the die one or more loose pieces and removing same from each casting after the latter is taken from the die, if the core is shaped the same as that for the semi-permanent mold. The die casting weighed 1.10 lbs., or about 25 per cent less than the permanent mold casting, indicating that a thinner section was used. In the only other direct comparison made available, a typewriter part, here illustrated, is produced in both permanent mold and die cast form. No production rates are given but, presumably because of savings in machine work, the die casting is 3.50 per cent lower in cost, in finished form, than the permanent mold casting. Both parts are in aluminum alloy.

Finishing Costs

Data made available to the author as to finishing costs are less specific than could be desired, but such costs are likely to favor the die casting, partly because closer dimensional limits and smoother surfaces are readily attainable, hence less metal need be cut away and less polishing will usually be needed on the die casting. Flash on the die casting is likely to be lighter and easier to remove. This applies in particular to the zinc alloy die casting over the permanent mold aluminum alloy type, but the latter is surely no easier to machine than the aluminum die casting of the same or similar composition. In respect to applied finishes, any advantages would lie with the die casting, partly because of its smoother surface. If plating is involved, the zinc alloy die casting ranks as easier to prepare for plating and to plate.

Section Thickness

A section thickness of 3/32 in. is usually named as the minimum wall thickness feasible in permanent mold die castings in aluminum alloy, although some of a thickness of 0.080 in. have been made and one producer states that waffle grids are cast successfully in 0.060 to 0.070 in. sections. As against this, 1/32 in. (0.031 in.) is readily secured in medium to small die castings in zinc alloy and some almost as thin have been made in aluminum alloy. Quite large zinc alloy die castings have been made with 0.050 in. average section thickness, whereas nearly twice this or heavier would be needed in a corresponding permanent mold casting in aluminum alloy. There is thus no question that the die casting can be made with thinner sections, as far as feasibility of casting is concerned.

On a strength basis, there may be cases in which the greater tensile strength feasible with permanent mold castings in *aluminum* alloy in heat-treated form might make it feasible to employ a thinner section than for a corresponding aluminum die casting. Also where strength is involved, the greater porosity likely or sometimes occurring in the die casting may have a bearing on the minimum sections which it is feasible to use, as indicated under the heading "Porosity." On the other hand, stiffness and even strength often requires that the thickness of either type of casting be well above the minimum which it is feasible to cast.

(To be concluded)

A Correlated Abstract

Precipitation Hardening Effects in "Plain" Ferritic Steels

by H. W. GILLETT

The regulation heat-treatment methods and results so occupy our minds in usual consideration of the treatment of steel, that some secondary phenomena are obscured.

Yet some of these apparently minor factors may have a real bearing on the final results.

Precipitation hardening is generally thought of in relation to non-ferrous alloys or to some complex and highly alloyed ferrous alloys. Actually the everyday steels appear subject to the precipitation-hardening type of phenomena.

It was long ago stated by Fry[1] and later emphasized by Neuendorff[2] that "Izett" steel is not as subject to "caustic embrittlement" in boilers as is ordinary boiler plate. This has not been substantiated in all American studies of caustic embrittlement, but it should be recalled that most of these studies have been made by chemists who were thinking solely of the action of the corroding media upon steel under stress, and who assumed that any piece of boiler plate of conventional composition as shown by analysis for the usual elements was equivalent to any other, and, likewise that any piece of "Izett" steel was equivalent to any other. Izett is a more or less heavily aluminum-killed steel.

Houdremont, Bennek and Wentrup[3] have reported a study of caustic embrittlement in particular relation to the killing of the steel. Their method of evaluation was to heat a bowed or otherwise stressed specimen in some one of several nitrate solutions and note when the specimen cracked. We will not here consider the details of their testing technique, nor whether such tests correlate with boiler performance; these are matters upon which those laboring in that field can argue, as they have argued analogous matters in the past. Whether the tests mean anything in relation to boilers or not, it can hardly be disputed that observed differences in behavior of different steels in such a test indicate differences in the steels.

Houdremont and co-workers subjected machined specimens from 90 heats of rimmed and 180 heats of strongly killed open-hearth steel to hot sodium nitrate solutions. The results were:

	Percentage Breaking In			
	1 to 6 days	6 to 35 days	6 to 60 days	Not broken in 300 days
Rimmed	79	10	..	11
Strongly killed	18	..	6	76

That is, among the rimmed heats 1 out of 10 was not susceptible to embrittlement, while among the killed steels 1 out of 4 was susceptible to the embrittling intercrystalline attack.

Most of Houdremont's later tests were made on sets of three duplicate bowed specimens heated at 212 deg. F. for 21 days in a calcium nitrate, ammonium nitrate solution, and data reported in terms of how many of the three specimens went through the 21 days without cracking. By such tests these authors convinced themselves that on steels with the rolling skin left on, and rolled and annealed in the customary fashion, those of 0.20 to 0.24 per cent C were generally, though not always, resistant, whether their aluminum content (this term in their report always means residual aluminum in metallic form, not as Al_2O_3) was high or low, whereas at 0.09 to 0.13 per cent C those with less than 0.03 per cent aluminum were not resistant, but those with more than 0.04 per cent aluminum were resistant. It was thought that surface decarburization might have an effect (the steels were tested as 0.2 in. thick sheet) so a killed 0.10 per cent C steel was annealed at 1700, 1975, and 2245 deg. F. in vacuum for 4 hrs. each. None of these treatments made the steel non-resistant. Four hrs. in CO_2 or 2 hrs. in steam at 1700 deg. F. did not make it non-resistant, but 4 hrs. in steam or 2 hrs. in either CO_2 or steam at the highest temperatures ruined it. Sufficient surface oxidation or decarburization or both, is thus shown fatal.

However, on trying an anneal in nitrogen, it was found that even 2 hrs. at any one of the three temperatures ruined their resistance. However, if instead of nitrogen, a mixture of 80 per cent N_2 and 20 per cent CO was used, the steel was still resistant after 6 hrs. at 2010 deg. F. To chase this down further, specimens were exposed to nitriding conditions in NH_3 at 930 deg. F. for 3, 6, 12, and 24 hrs., but all of these were resistant. However, if any of these were heated ½ hr. at 1700 deg. F. and air cooled, their resistance was ruined. Houdremont cites Klinger and Koch[4] that non-aging sheet carries 0.01 to 0.02 per cent N_2 for a depth of 0.004 to 0.008 in. on the surface after rolling and annealing with only 0.004 per cent deeper in the sheet. Houdremont thus concludes that heat treatment, as well as composition, is involved.

Tests on 18 Heats

A series of 18 heats, 0.10 to 0.12 per cent C of varying aluminum content, had the rolling skin removed, and were then heat treated in various ways. Heated ½ hr. at 1700 deg. F. and air cooled, 11 heats that had from 0.01 to 0.04 per cent aluminum and which remained fine grained, were fully resistant; 7 heats with under 0.02 per cent aluminum, which also remained fine grained, were not resistant. Of the same 18 heats, annealed 2 hrs. at 1740 deg. F. and furnace-cooled, only 3, all with about 0.02 per cent aluminum and which remained fine grained, were completely resistant, while the other 15, with a range of aluminum contents and with a variety of coarsening responses, were poorly resistant, those that coarsened materially were all bad, but some were bad whether they had coarsened or not. On heating the 18 lots to 2190 deg. F. for 2 hrs. and furnace cooling, all coarsened and all were practically ruined in resistance to intercrystalline attack, though three of the steels with highest aluminum contents were perceptibly, though only slightly, better than the rest.

Over heating and slow cooling were thus shown to be detrimental.

Another series of four steels from which the rolling skin had been removed was used in which the aluminum content varied from 0.02 to 0.11 per cent. When air cooled from 1700, 1830, or 1920 deg. F. the steel with 0.02 aluminum was not resistant, those with 0.04 to 0.1 per cent aluminum were fully resistant; on air cooling from 2010 deg. F. the steel with 0.02 per cent aluminum was, as always, not resistant, while that with 0.11 per cent aluminum was still resistant, those of 0.04 and 0.06 per cent were only partly resistant. But when the 0.11 per cent aluminum steel was furnace cooled from 2190 deg. F. it completely lost its resistance.

Treatment below the critical was then tried on 18 heats, none with more than 0.02 per cent aluminum, all of which were totally non-resistant to intercrystalline attack when heated ½ hr. at 1700 deg. F. and air cooled when the rolling skin was left on, and none were completely resistant even though the skin had been removed. Heating these (with skin removed) at 1345 deg. F. for 2 hrs. and air cooling, made 10 of the 18 fully resistant; at 1345 deg. F. for 2 hrs. and furnace cooling made 13 fully resistant, and 2 hrs. at 1200 deg. F., furnace cooled, made 14 of them fully resistant. If the rolling skin was left on, the improvement was less complete, but still very evident. However, the range of aluminum content in the steels, with the skin on or off, that were made fully resistant by these treatments below the critical, covered the same range, 0.005 to 0.02 per cent aluminum, that was present in the steels that, while improvable, were not made fully resistant.

Another Series of 18 Steels

Another series of 18 steels with 0.10 to 0.12 per cent C and 0.005 to 0.04 per cent aluminum were first heated ½ hr. at 1700 deg. F. and air cooled, then cold rolled 7 per cent and furnace cooled after 15 hrs. at 1255 deg. F. Thirteen of the 18 were fully resistant. Duplicating this test except that the cold rolling was some 25 per cent, 15 became fully resistant. Again, the series, after the normalizing from 1700 deg. F., was cold rolled 15 per cent, heated 2 hrs. at 1250 deg. F. and air cooled, then cold rolled a further 15 per cent, again heated 2 hrs. at 1255 deg. and air cooled. Of the 18, 12 were fully resistant. The two steels of 0.03 to 0.04 per cent aluminum in these three series of cold rolling and heat-treating tests, were always fully resistant.

Quenching and tempering were carried out on a 0.26 per cent C strongly deoxidized steel. As water quenched from 2100 deg. F. or drawn ½ hr. at temperatures up to 575 deg. F. there was no resistance to intercrystalline attack, if drawn at 1110 to 1200 deg. F. the resistance was complete. A steel of 0.30 C, 2.00 Ni, 2.50 per cent Cr, oil quenched from 1510 deg. F., as quenched, or drawn 2 hrs. at temperatures up to 900 deg. F., was non-resistant, but if drawn at 1200 deg. F. it was fully resistant.

In a series of 4 steels, all of about 0.10 per cent C, A was a rimmed Bessemer, B a rimmed open-hearth, C a weakly killed open-hearth and D a strongly killed open-hearth steel. These were quenched in ice water, in oil, in air (normalized) or furnace cooled from 1700 deg. F. after ½ hr. at that temperature. When tested for intercrystalline attack, each one acted differently. Two out of three samples of the water quenched Bessemer steel A were resistant to intercrystalline attack, all three were resistant when quenched in oil, none were at all resistant when more slowly cooled. The rimmed open-hearth B showed only one out of three resistant when oil quenched, the water quenched and the air and furnace cooled lots were not resistant. The

weakly killed steel C showed all three specimens fully resistant when oil quenched, none were resistant at more rapid or slower cooling rates. The strongly killed steel D was fully resistant when oil or air quenched, not resistant as water quenched or furnace cooled.

These four steels were then given the ordinary 1700 deg. F. anneal after which they were reheated to 1255 deg. F. for 2 hrs. and cooled in ice-water, oil, air, or the furnace. No steel showed any fully resistant specimen (save one of the 3 specimens of the fully killed steel D cooled in air) at any of the three more rapid rates of cooling, whereas, when furnace cooled from 1255 deg. F., steels A and B gave one out of three; steel C two out of three, and steel D, all three specimens, fully resistant.

Behavior of a Rimmed Open-Hearth Steel

A rimmed open-hearth steel was quenched in oil from 1700 deg. F. It was not fully resistant as quenched, but when drawn at 210 to 930 deg. F. for 4, 8, 12, 50, 200 or 800 hrs., it became fully resistant. The draw temperatures were carried up to 1290 deg. F. in the cases of the 4, 8, and 12 hr. draw times and the specimens were fully resistant when the draw temperatures did not exceed 1150 deg. F. The resistance to intercrystalline attack then decreased till it was lost at 1290 deg. F.

Then a rimmed open-hearth steel was given the usual ½-hr. heating at 1700 deg. F., air cooled and reheated for a wide range of times and temperatures. The susceptibility to intercrystalline corrosion was at a minimum under two reheating treatments, either 1150 to 1200 deg. F. for 2 hrs. (increasing the time to 4 hrs. gave material very readily attacked) or 575 to 750 deg. for ½ hr. Increasing the time at this temperature range injured the material, but not so badly as at the higher range. The plot of days life in the hot nitrate solution is very reminiscent of the shape of the familiar S-curve for austempering.

A Conclusion

These observations lead to the conclusion that a precipitation hardening type of action takes place, ferrite becoming supersaturated with some precipitable material which can be thrown out either throughout the crystal or preferentially in the grain boundaries. While one could postulate that the grain boundary effect is due to lack of particles there rather than to an accumulation, it seems more probable that it is due to an accumulation. Then the "caustic embrittlement" or intergranular corrosion effect would be an indicator of a grain boundary accumulation of the precipitate. Aging phenomena, i.e. embrittlement to notched impact after cold working and reheating seem to parallel the caustic embrittlement phenomena, but it is more difficult to prevent caustic embrittlement than to prevent aging.

The less thoroughly deoxidized the steel is, e.g. the lower the carbon, other things being equal, and, for a given degree of oxidation of the melt, the smaller the aluminum addition, the more readily does the precipitate accumulate at the grain boundaries. Fine grained steels appear less susceptible, perhaps because there is more grain boundary area in which to disperse a given amount of precipitate, or because there is less of the soluble and precipitable material in a steel that has been so deoxidized as to be difficultly coarsenable. But neither a mere content of excess metallic aluminum nor mere fine grain suffices to prevent the solution and precipitation phenomena. Steel can be very susceptible and still show fine grain, and, with sufficient overheating and a slow rate of cooling, even 0.11 per cent metallic aluminum may not prevent susceptibility.

Each heat of steel seems to respond to solution and precipitation heat treatments in a rather individual way, which seems to hark back to the condition of oxidation of the melt at the time the aluminum is added, and to the amount of aluminum added. There is some evidence that nitrogen is one of the precipitable materials. It is logical to suppose that Al_2O_3 is another, and the similarity of the intercrystalline corrosion plot to the S-curve indicates that, at least in the absence of aluminum, iron carbide may play a part.

Proper Deoxidation and Heat Treatment

At any rate, this work should be an eye-opener to the workers on caustic embrittlement who take the position that "steel is steel" and neglect the opportunities for avoidance of caustic embrittlement through proper deoxidation and heat treatment practice. This metallurgical naiveness ought not to persist, with data like these on record.

The similarity of behavior with known precipitation in hardening phenomena is very great. Thin sheet duralumin quenched in water from the solution temperature is free from intercrystalline corrosion, while that quenched in oil is prone to it. This is clearly a grain boundary effect, which also has its counterpart in the grain boundary carbide embrittlement of austenitic stainless steels and heat-resistant alloys.

The separation of one precipitable compound may be accelerated by the presence of another; duralumin has two such compounds, $CuAl_2$ and Mg_2Si. In duralumin the separation of both precipitates occurs at room temperature, while if duralumin is unscrambled into two alloys, one that can only precipitate $CuAl_2$, the other one that can only precipitate Mg_2Si, both of these alloys require reheating to above room temperature.

So while the phenomena are in steel subject to caustic embrittlement, clearly these of a precipitation hardening type, it is not necessary that the behavior be due to one single precipitable compound.

This pattern by which ferritic steels act like precipitation-hardening alloys is evidenced by much other proof than that already quoted for intergranular corrosion. Much more could be collected in relation to effects that appear to be vastly influenced by grain boundary relations, and which often appear to be at least roughly correlated with grain size, but which may actually be much more directly correlated with accumulations of a precipitate at the grain boundaries.

Precipitation Effect of Impurities

Epstein[5] studied the embrittlement of Bessemer, open-hearth duplex and Izett steels, both in respect to the transition temperature at which loss of impact resistance occurs, and as to susceptibility to embrittlement by cold work. In both cases the Bessemer was the poorest and the Izett the best. He discusses the relation of embrittlement to "precipitation effects of impurities," considers it reasonable that nitrogen plays a part, and presents micrographs indicating that grain boundary "carbides" go into solution at 1200 deg. F. and can be precipitated by reheating at lower temperatures. He comments that "ordinary iron and steel, which we usually consider free from precipitation phenomena, are really permeated with such effects."

Further evidence along this same line was presented by Herty and McBride[6] who explored the impact resistance of some steels of 0.14 to 0.22 per cent C down to —65 deg. F. They found a rough relationship between the retention of low temperature toughness and the initial deoxidation of the melt, the amount of metallic aluminum after deoxidation, and the grain size, or, more strictly, the propensity toward coarsening upon heating. Steels with 0.025 to 0.04 per cent metallic aluminum were in one category, with good retention of toughness, while the silicon killed, semi-killed or rimmed steels were in another, with great loss of toughness. The good steels could be injured by overheating that increased the grain size, a common observation, but they were also injured by overheating that did not produce grain coarsening.

That is, "coming events threw their shadows before." Herty and McBride state that their observations "indicate very plainly that over-heating, in addition to causing grain growth, may cause a loss of impact value due to an increase in the solid solution material, or a change in the type of suspension in the steel."

Schane[7] in an early discussion of grain size, pointed out that substances that inhibit grain growth have some degree of solubility in austenite, and can be rejected to grain boundaries at lower temperatures. Dorn and Harder[8] presented a similar point of view in connection with experiments of steel of medium carbon content. Boulger[9] reported other cases where "coming events threw their shadows before" in respect to decrease of impact resistance on heating prior to coarsening.

That the low-temperature loss of impact resistance may be due to the presence of precipitated particles is mentioned by Kinzel[10].

Mitsche[11] comments on the ability of the so-called "forging cross" to be affected by heat treatment in a plain 0.45 per cent C rather low manganese steel and describes the behavior to the varying distribution of non-metallic nuclei in the slip planes. Localized grain growth, upon which he comments, indicates a segregation of the non-metallic material during freezing—so that not only different heats, but even different locations in the same bar, may act in an individualistic manner.

Variation Due to Segregation

This variation due to segregation is commented upon by Graham and Work[12] in respect to the impact resistance of cold-worked steel from different portions of an ingot. The sensitivity to cold work seems, like aging, intercrystalline corrosion, and low temperature brittleness, to be closely allied with the methods of deoxidation of the steel.

That individual heats of steel act in an individualistic manner in respect to low temperature impact, so that "the present state of the art does not permit use of composition, grain size and heat treatment as criteria for resistance to impact, which indicates the advisability of subjecting each lot to test" and that "the form and distribution of the soluble constituents in ferrite has an effect" are brought out by Armstrong and Gagnebin[13], and Rosenberg[14] brings out the same point as to individuality of behavior.

That is, precipitation hardening effects occur, presumably through solution and precipitation of non-metallics, which are evidenced by the response to low temperature notched-bar impact testing, and the vagaries of individual steels may well be due to this cause.

Quench Hardenability

Recent literature is replete with individual cases where the quench hardenability of certain particular steels is not in accord with expectations based on grain size. These differences in behavior can not be just innate cussedness; they must be the results of the solubility and precipitability of the particular compositions, size and distribution (all unknown because of the sub-microscopic size of the precipitate) of non-metallics resulting from the state, i.e. composition as to inclusion-forming material, of the melt at the time of adding "deoxidizers," and the kind and amount of "deoxidizer" added. Whether the precipitate comes out within the grains or at the boundaries is a hair-trigger matter, greatly affected by rate of cooling, just as in the case of carbide embrittlement of "18 and 8."

In the production of non-aging steels, of steels resistant to inter-granular corrosion, and of those of good low-temperature impact the production of fine

grained, heavily aluminum-treated, difficulty coarsenable steels appears to be an important step in the right direction, though this may go for naught if a wrong heat treatment is applied so that grain boundary precipitation ensues.

In another type of service for ferritic steels, that of carrying load at the highest range of temperature that such steel will serve for, the important step appears to be in just the opposite direction, i.e. aluminum treatment may have to be avoided, an easily coarsenable steel produced, and a heat treatment applied that will coarsen it. However, unalloyed rimmed steel, even though it has been coarsened, shows extremely poor high temperature load carrying ability. Silicon-killed steels, with only a restricted amount of aluminum addition, are usually specified.

Cross and Lowther[15] noted that "coming events threw their shadows before" in this connection also, since creep resistance of certain steels was greatly improved by a heating that did not coarsen the grain size at all.

Of two steels, both deoxidized with 2 lbs. of aluminum per ton, and otherwise alike except in silicon content (one of 0.15 C, 0.45 Mn, 0.02 Si, 0.02 S, 0.01% P, the other of 0.17 C, 0.48 Mn, 0.16 Si, 0.03 S, 0.02% P), with the same heat treatment (so selected that the grain sizes of both were fine and equal), the low silicon steel was much the poorer. The two steels responded very differently to slow cooling rates from their respective coarsening temperatures. It seems clear that "grain sizes as such are not the controlling factors in determining creep resistance, but are the outward or pyrometric indication of the heat treatment given to the steel which produced the observed creep test results."

In creep, as in intergranular corrosion and in low temperature impact behavior, the condition of the grain boundaries, i.e. the presence or absence of precipitated particles at the boundaries, seems to play a vital part. However, in the case of creep, it may well be that an important factor is the way the slip planes within the grains are keyed, so that it may be that it is not so much the presence of particles at the boundaries, as it is their relative absence within the grains that counts. The important effect on creep of the presence of precipitated particles was shown as probable by Cross and Lowther who found that in spite of its fine grain, a vanadium steel had excellent creep resistance. Precipitation hardening effects in vanadium steels are well known. This point of view was made entirely tenable by the work of Miller, Campbell, Aborn and Wright[16] who showed microscopic evidence of a fine shower-precipitate in molybdenum-containing, creep resistant steels which has a strong tendency to come out within the grains rather than to separate at or migrate to grain boundaries.

Thus it is quite possible that the poor behavior of rimmed steel, even when coarse grained, is due to the lack of a proper keying precipitate within the grains, and that if such a precipitate could be provided, the poor behavior could be overcome.

Irritating Individuality of Carbon Steels

So, much of the funny business by which ordinary carbon steels display irritating individuality appears to be due to the fact that they are really responding to their content of ferrite-soluble materials and to the solubility curves for these materials, in accordance with which precipitation occurs, either as a shower throughout the grain, or as an accumulation at the grain boundaries, according to the cooling rates and reheating temperatures and times, just as do the well-behaved and well-understood precipitation hardening alloys in which metallic compounds form the precipitate. The obscurity lies in that, in the steels, one is not sure what the compounds are, and the amount of them necessary to produce effects is so small that it is difficult to deduce, from intentional changes in composition of the melt, just what they ought to be. Also, the effective particles are so small that they cannot yet ordinarily be shown up by microscopic examination.

Nevertheless, it is a step in advance to have the general acceptance now being manifested by many workers, of what seems to be an understandable general pattern of behavior. That understanding may well lead to an ultimate ability to handle the melts and heat treat the solid products so that the desired precipitate will come out where it is desired, in reliable and reproducible fashion.

References

1 A. Fry. "Izett-Eisen," *Z. bayer. Revisions-Ver.*, Vol. 32, 1928, pages 137-140, 150-153, 164-166, 183-184.

2 G. G. Neuendorff. "Izett Steel, What it is and what it is used for," *Metals and Alloys*, Vol. 3, March 1932, pages 61-68.

3 E. Houdremont, H. Bennek & H. Wentrup. "Erforschung und Bekämpfung der interkristallinen Korrosion des unlegierten Stahles," *Stahl u. Eisen*, Vol. 60, 1940, pages 757-763, 791-797.

4 P. Klinger and W. Koch. "Microchemical Determination of Nitrogen in Steel with Especial Consideration of the Examination of the Surfaces," *Tech. Mitt. Krupp*, Vol. 5, 1937, pages 61-67.

5 S. Epstein. "A Study of the Embrittlement of Hot Galvanized Structural Steel," *Proc. Am. Soc. Testing Materials*, Vol. 32, Pt. 2, 1932, pages 293-379.

6 C. H. Herty, Jr. and D. L. McBride. "Effect of Deoxidation on Impact Strength of Carbon Steels at Low Temperatures," *Coop. Bull. No. 67*, Min., Met. Adv. Boards to Carnegie Inst. Tech. and U. S. Bur. Mines, 1934, 43 pages.

7 P. Schane. Discussion, Trans. Am. Soc. Metals., Vol. 22, 1934, pages 1034-1035.

8 J. E. Dorn and O. E. Harder. "Relation of Pre-treatment of Steels to Austenitic Grain Growth," *Trans. Am. Soc. Metals*, Vol. 26, 1938, pages 106-126.

9 F. W. Boulger, cited in D. K. Bullens's and Battelle Memorial Institute's "Steel and Its Heat Treatment," Vol. 1, 1938, page 244, published by John Wiiey and Sons, New York.

10 A. B. Kinzel. "Minute Non-ferritic Particles in Steel," *J. Applied Phys.*, Vol. 8, 1937, pages 341-344.

11 R. Mitsche. "The 'Forging Cross' in Square Billets," *Metal Progress*, Vol. 39, Mar. 1941, pages 335. 360.

12 H. W. Graham and H. K. Work. "A Work-brittleness Test for Steel," *Proc. Am. Soc. Testing Materials*, Vol. 39, 1939, pages 571-580.

13 T. N. Armstrong and A. P. Gagnebin. "Impact Properties of Some Low Alloy Nickel Steels at Temperatures down to —200 deg. F.," *Trans. Am. Soc. Metals*, Vol. 28, 1940, pages 1-24.

14 S. J. Rosenberg. "Effect of Low Temperatures on the Properties of Aircraft Metals," *J. Research Natl. Bur. Standards*, Vol. 25, 1940, pages 673-701.

15 H. C. Cross and J. G. Lowther. "Study of Effects of Manufacturing Variables on the Creep Resistance of Steels," *Proc. Am. Soc. Testing Materials*, Vol. 38, Pt. 1, 1938, pages 149-171; Vol. 40, 1940, pages 125-153.

16 R. F. Miller, R. F. Campbell, R. H. Aborn and E. C. Wright. "Influence of Heat Treatment on Creep of C-Mo and Cr-Mo-Si Steel." *Trans. Am. Soc. Metals*, Vol. 26, 1938, page 81. See also R. F. Miller, W. G. Benz and W. E. Unverzagt—"The Creep Strength of 17 Low-alloy Steels at 1,000 deg. F.," *Proc. Am. Soc. Testing Materials*, Vol. 40, 1940, pages 771-781; and P. E. McKinney, Discussion, *Proc. Am. Soc. Testing Materials*, Vol. 38, Pt. 2, 1938, page 190.

Tempering Air-Hardened Tool Steel

Secondary Hardening Without Distortion

By W. HUGHES WHITE

Faitoute Iron & Steel Co., Newark, N. J.

IN MOST TYPES OF TOOL STEEL, it is common to experience some size change, or distortion during hardening. This amount of change is variable, dependent upon many factors, including steel analysis, quenching temperature, rate of heating, size and shape of part, quenching medium, etc. It is generally accepted that the minimum distortion or size change takes place in the air hardening type of high-carbon, high-chromium tool steel. A typical analysis of this type of material would be within the following range:

	Per Cent		
Carbon	1.50	to	1.63
Manganese	0.35	to	0.40
Silicon	0.24	to	0.48
Chromium	11.07	to	12.20
Molybdenum	0.71	to	0.84
Vanadium	0.25	to	0.26
Cobalt	0.00	to	0.45
Sulphur	0.010	to	0.016
Phosphorus	0.015	to	0.024

In order to determine the means of attaining extreme accuracy on such applications as do not permit any grinding or other surface change after the hardening operation has taken place, five pieces of this material were obtained from warehouse stock, each within the above analysis. These represented the products of four different tool steel mills. These were machined into test pieces of the shape and section shown in Fig. 1. All were accurately measured individually in the annealed condition, after air quenching and after each successive drawing cycle. The basic annealed measurements and average size change for each dimension are shown in the Table.

An analysis of the results obtained from these test pieces would indicate the following significant facts:

1. A secondary hardness is obtained by a drawing temperature of 900 to 950 deg. F.
2. This secondary hardness is accompanied by a return to exact size of annealed material (within usual range of accuracy).

These results are shown in a graphic form in Fig. 2. The theory is advanced that since this material is usually air quenched from a temperature of 1850 deg. F., that there is a certain amount of austenite retained in the as-quenched material, which is lower in volume than martensite and accounts for the slight shrinkage. This austenite is sluggish in transformation, but accomplishes a complete change at the drawing temperature of 900 to 950 deg. F.

By proper use of these facts it is possible to obtain the excellent wearing properties of the high carbon, high chromium tool steels and also produce parts which will not require grinding after hardening to obtain accurate size.

Table of Basic Annealed Measurements, and Average Size Change for Each Dimension in Inches

Size Annealed	A 3.5000	B 3.5000	C 3.5000	D 3.5000	E 1.3750	F 1.0000	G 1.0000	H 0.5620	I 1.1250	Average Size change in in./in.	Hardness 190/229 BHN
Size change as quenched	—.00082	—.00100	—.00046	—.00042	—.00028	—.00030	—.00006	+.00022	+.00054	—.00019	62/65 RC
As drawn at 300°F. 1 Hr.	—.00166	—.00178	—.00166	—.00114	—.00080	—.00074	—.00046	+.00006	+.00046	—.00051	60/63 RC
As drawn at 400°F. 1 Hr.	—.00184	—.00180	—.00168	—.00128	—.00082	—.00084	—.00030	.00000	+.00044	—.00048	59/62 RC
As drawn at 400°F. 2 Hr.	—.00186	—.00182	—.00180	—.00136	—.00084	—.00096	—.00022	—.00008	+.00038	—.00053	58/63 RC
As drawn at 500°F. 1 Hr.	—.00206	—.00210	—.00186	—.00186	—.00092	—.00104	—.00034	—.00017	+.00010	—.00060	57/61 RC
As drawn at 600°F. 1 Hr.	—.00212	—.00234	—.00220	—.00208	—.00104	—.00104	—.00040	—.00022	.00000	—.00067	57/60 RC
As drawn at 900°F. 1½ Hr.	—.00330	—.00342	—.00292	—.00310	—.00138	—.00134	—.00074	—.00026	—.00062	—.00096	57/61 RC
As drawn at 950°F. 1½ Hr.	+.00066	+.00054	+.00076	+.00080	+.00032	—.00026	+.00052	+.00038	+.00058	+.00018	58/61 RC
As drawn at 1000°F. 1½ Hr.	+.00214	+.00178	+.00200	+.00202	+.00076	+.00016	+.00062	+.00066	+.00096	+.00051	55/58 RC

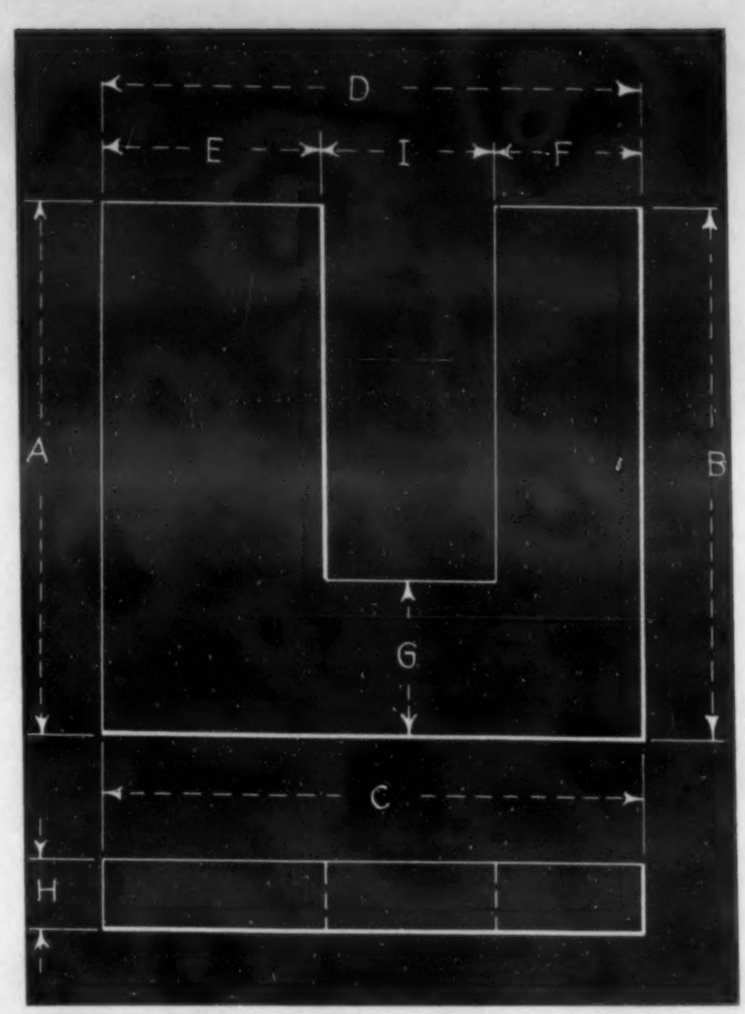


Fig. 1. Showing shape and section of test piece.

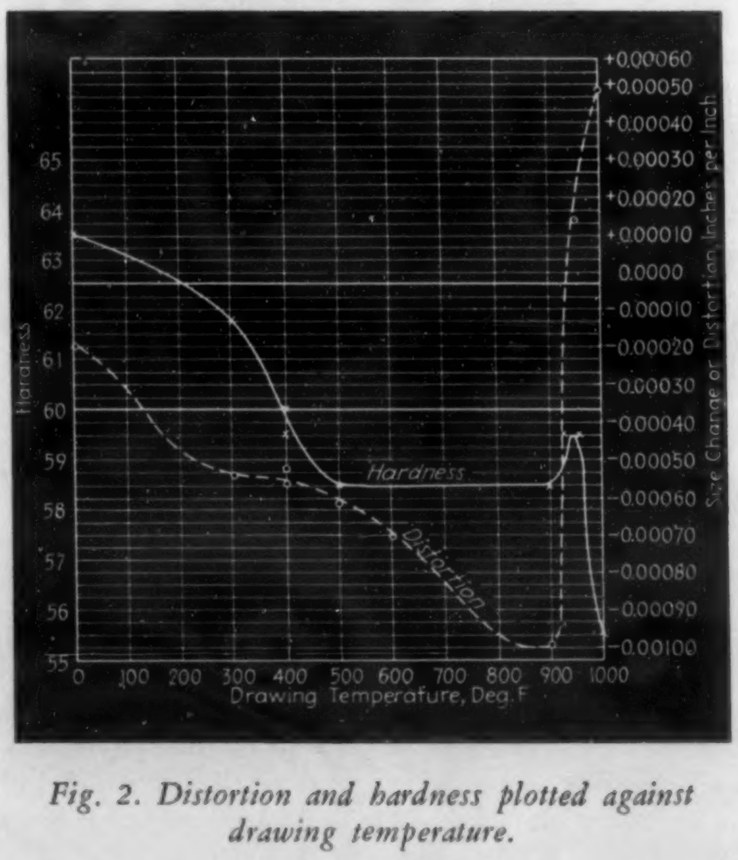


Fig. 2. Distortion and hardness plotted against drawing temperature.

Indium and Other Elements

Only recently has indium become available in limited commercial quantities. As a result some researches on its possible uses as an alloying element have been, and are still being, conducted.

This article discusses some of the results of an investigation on the effect of indium on heat-treatable aluminum alloys, a subject on which very little has been published. It has been found that small amounts of indium have a decided influence on the age hardenability of these alloys. The increase in hardness during aging is reported as remarkably high. This fact, as well as the other that hardening takes place at a slower rate in the duralumin type of alloy and at a faster rate in alloys without magnesium, is of some technical interest.—The Editors.

Very little is known about the influence of indium on the properties of technical metals and alloys, although this formerly rare metal is now available in sufficient quantities to be of commercial interest.

In the course of investigations on the effect of indium on various alloys it was found that small amounts of indium have a marked influence on age hardenable aluminum alloys. The results of Brinell hardness measurements are briefly summarized in the following note.

Material and Method

All of the alloys of this investigation were prepared from metals of commercial purity; conductivity aluminum, wirebar copper, electrolytic manganese and pure indium. Except for small amounts of silicon (0.15% Si) and iron (0.30% Fe), the resulting alloys were comparatively pure. The addition of indium to the aluminum base alloys was easily accomplished and vertical castings about 0.4 in. thick were made in a preheated mold. The castings were hot rolled to about 0.2 in. and it was found that the indium-bearing alloys containing magnesium were somewhat more difficult to roll. Samples of the rolled sheets were solution treated at 500 deg. C., quenched in cold water and the Brinell hardness determined, using a 10 mm. ball and 500 kg. load. Some alloys were aged at room temperature and others at 120 to 150 deg. C., depending upon the type. Brinell hardness measurements were continued until the hardness had become constant or in some cases had started to decrease.

Data

The alloys of the duralumin type which age at room temperature do not become harder with the addition of indium, although the rate of hardening is considerably lowered as is shown in Fig. 1, giving as examples the results on alloys of aluminum with about 4 per cent Cu, 0.5 per cent Mg without indium (No. 14) and with 0.1 per cent In (No. 16), and on alloys with 4 per cent Cu, 0.5 per cent Mg and 1 per cent Mn without indium (No. 42) and with 0.13 per cent In (No. 43). On the left side of the diagram the Brinell hardness numbers for the first 5 hrs. at room temperature after quenching are recorded, and on the right side the numbers after 1 to 11 days.

On the other hand alloys without magnesium show a marked increase in hardness with the addition of indium as shown in the table. An indium content of 0.1 to 0.2 per cent gave results not ex-

Table of Effects of Indium on Age Hardening of Aluminum-Copper Alloys

Without Indium				With 0.05% Indium		With 0.1-0.2% Indium	
Alloy No.	Composition	Max. B. H. N.	Increase during Aging	Max. B. H. N.	Increase during Aging	Max. B. H. N.	Increase during Aging
A	Al + 4-4.5% Cu	93, 93, 87, 95, 86, 82 / Ave. 89	32	110	56	114, 124, 109, 125, 109, 125 / Ave. 116	63
B	Al + 4.5-5% Cu	98	34	117	62	126	67
C	Al + 4-4.5% Cu + 1% Mn	109	36	114	47	119	38
D	Al + 4.5-5% Cu + 1% Mn	113, 109 / Ave. 111	38	116	42	122	41

In Age Hardenable Aluminum Alloys

BY W. H. FRAENKEL

Research Department,
Amer. Smelting & Refining Co.,
Barber, N. J.

ceeding the limits of experimental error and these results are tabulated together. As can be seen, the influence of indium is greater on alloys containing only copper, and the addition of manganese decreases the effect of indium.

Effect of Other Metals

It was not likely that indium has a completely unique influence on these alloys and the investigation was extended by replacing indium with neighboring metals in the periodic table, such as silver, cadmium, tin, antimony, tellurium and thallium.

As the effect of indium was most pronounced on aluminum alloys containing about 4 per cent Cu, 0.1 per cent of each of the above mentioned elements were added to this alloy. The metals cadmium and tin not only increase the hardness in a manner similar to indium but the rate of hardening also increases markedly with increasing atomic weight from silver to tin. The next element antimony has only a very small influence, and tellurium decreases the rate of hardening, as does thallium. The influence of silver is small and can just be observed.

In Fig. 2 the results of the experiments with alloys containing silver, cadmium, indium and tin are given. On the left side of the diagram the Brinell hardness numbers just after quenching are recorded, then follows the hardness after one day at room temperature. The samples were then aged at 140 deg. C. with the resulting hardness numbers as shown on the curves. The well known decrease in hardness which takes place when the temperature of hardening is increased was observed on some of these alloys.

The investigation is as yet confined to only hardness tests and experimental data are too few to allow theoretical considerations. Nevertheless the results seem to be of considerable interest. Aluminum alloys of the same hardness are already known but they contain either more copper or manganese or other elements which produce greater hardness in the quenched condition. In the alloys mentioned in this paper the hardness after quenching is low, allowing easy deformation by mechanical means. The increase in hardness during aging is remarkably high. This fact, as well as the other that hardening takes place at a slower rate in the duralumin type of alloys and at a faster rate in alloys without magnesium may be of technical interest.

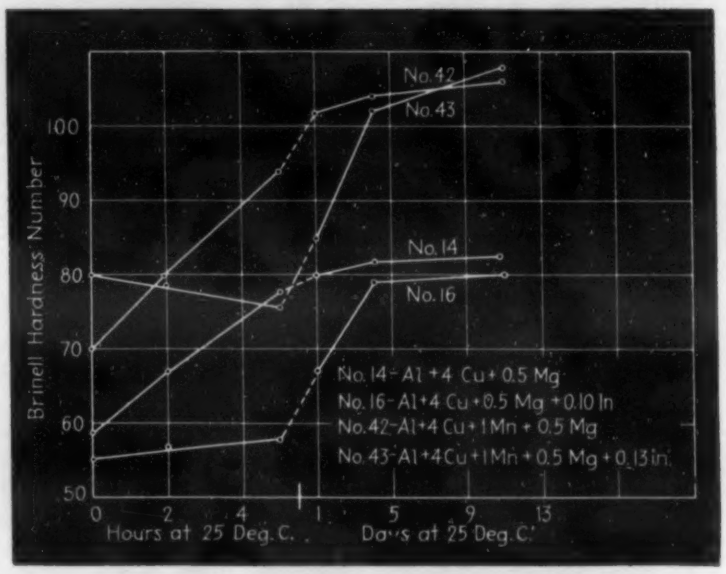


Fig. 1. Effect of indium on age hardening in alloys of the duralumin type. On the left side are the Brinell hardness numbers for the first 5 hours at room temperature after quenching; on the right side, the numbers after 1 to 11 days.

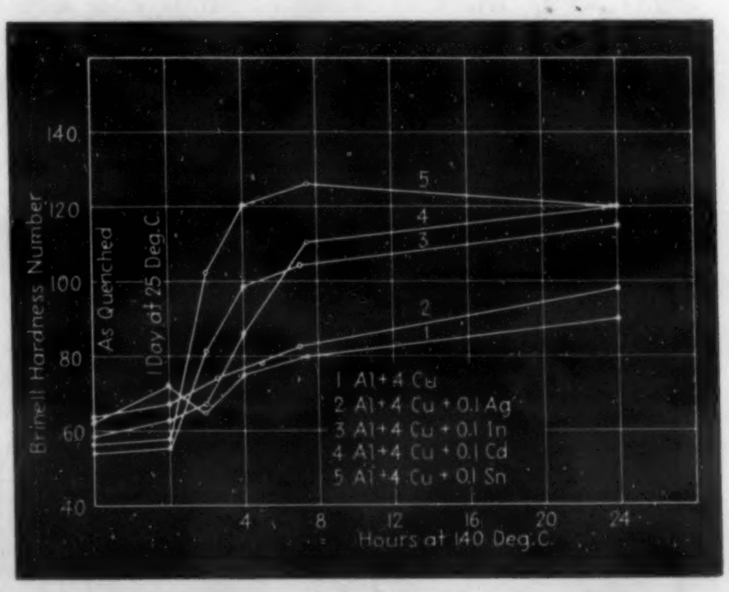


Fig. 2. Results of the experiments with alloys containing silver, cadmium, indium and tin. At the left the Brinell hardness just after quenching; then follows the hardness after aging at room temperature.

Radium Containers of High Density Metallic Aggregates

by HERMAN F. KAISER

Naval Research Lab., Anacostia Station, Washington, D. C.

This article describes an ingenious design for a metal shipping container for radium for use in radiography and medical applications. Some metallurgical tricks are involved in its construction—the use of steel, a heavy and liquid metal (tungsten and mercury) and also plastics. The new container is said to be as satisfactory as well as cheaper than the tungsten-nickel-copper one, produced from powdered metals, and developed in England a few years ago. —The Editors.

To protect persons from harm due to gamma radiation, radium is usually stored in heavy lead containers when not in use. The choice of lead for this purpose is not due to any property peculiar to lead, but rather to the fact that lead is an inexpensive metal which may be easily cast or worked into shape. The absorption of gamma radiation in a metal is mainly a scattering process and the absorption will depend directly on the amount of scattering matter per unit volume or density. Thus almost any metal may be used if only enough is used.

Where the weight of a radium container is no consideration, lead is the ideal material to use, but cases often arise where the weight of the radium container must be kept within reasonable limits. In hospitals, use is made of spherical radium applicators which, due to the high strength of the enclosed

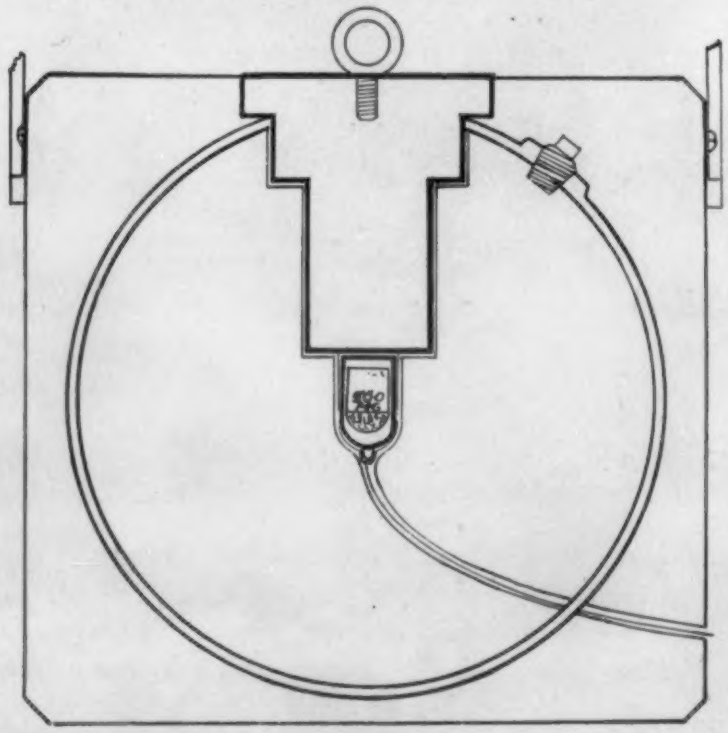


Fig. 1. Cross-section of radium carrier safe for a 500-mg. radium cartridge.

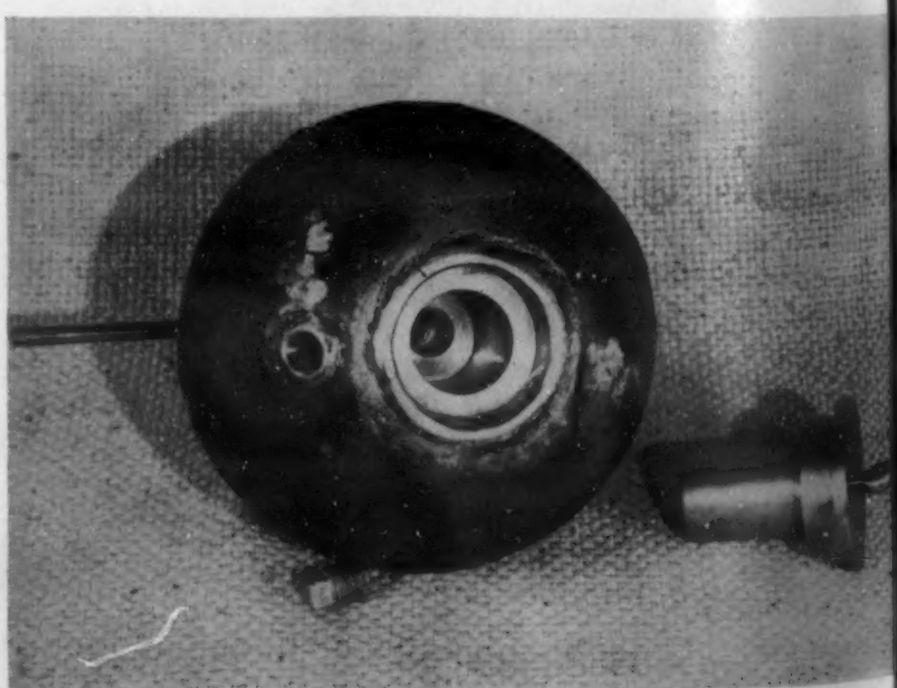


Fig. 2. Steel housing and hollow plug for radium carrier shown in Fig. 1.

Fig. 3. Steel radium cartridge and magnetic handling device.

radium (sometimes several grams), are of necessity quite heavy and require special heavy supporting mechanisms. To save weight parts of these applicators have been made of gold, or of high density tungsten-nickel alloys fabricated by powder metallurgy, as described by C. J. Smithells[1]. Both of these expedients are expensive, to say the least.

In radiography with gamma rays the radium or radium source is transported to and from the inspection site in a compact lead carrier. The weight of this carrier should not be so great that one person cannot move it easily, yet its wall thickness must be sufficient to give adequate protection while in storage or in shipment. In Naval gamma radiography it has been customary in the past to use a lead container having a wall thickness of 2 in. with a 1-3/4-in. diameter internal cavity.

Regulations Regarding Shipments

In May, 1939, Railway Express, Inc., issued a set of regulations regarding shipment of radium via express. These regulations are, in part, contained in the Table, which gives the allowed shipping time for any radium preparation up to 600 mg. when enclosed in lead containers of various wall thicknesses. Tests at the Naval Research Laboratory showed that these allowed transit times are only a fraction of the time required to produce photographic densities equal to the film's own fog level, but in view of continued improvement in sensitivity of radiographic film, they are reasonable enough.

From the Table it may be seen that a 2-in. wall carrier of the type mentioned above is allowed a transit time of 17 hrs. for a 250-mg. unit, and only 8.5 hrs. for a 500-mg. unit. This has imposed a restriction on the shipment of radiographic units necessitating a change in design of the carrier safe. As a first step it was desired to eliminate as much of the central cavity as possible by changing the design of the radium cartridge and constructing it of steel, so that it could also be easily handled by a magnetic transfer device shown in Fig. 3. The possibility of still further improvement of the carrier by use of metals having densities greater than that of lead was then investigated. This was found to be attended by practical and economical difficulties. With the exception of tungsten and uranium, which are expensive enough, metals having densities over 15 are precious metals, such as gold, iridium, osmium, etc. Tungsten and uranium (powdered) sell at prices of around $5 and $10 per lb. respectively. To get either in the forms desired requires the methods of powder metallurgy, which are costly when the size of the object is large. A radium carrier with a diameter of around 6 in. will cost about $1500, at the least.

High Density Metals Used

To avoid these difficulties the radium carrier was designed so that an aggregate of high density metals could be used. Figs. 1 and 2 show the construction of a radium safe designed for a 500-mg. steel radium cartridge. The steel shell of the body is easily produced by quickly emptying a filled spherical

mold two or three seconds after pouring. The other parts of the body are readily turned from bar stock and assembled by welding. The cavities in the plug and body are first filled with Bakelite resinoid, emptied, and baked to produce a hard-baked surface. The cavities are then loaded with tungsten rod or disc scrap jarred to pack as closely as possible. The interstices are finally filled with either mercury or lead. Using the mercury-tungsten filling it was found possible to obtain an average aggregate density of 17.2 which is as good as can be obtained in sintered W-Ni-Cu alloys. (Smithell[1] gives densities of 16.3-16.5 for 90 per cent W, 5 per cent Cu, 5 per cent Ni alloys and >17 for those containing less Cu or Ni.) When the interstices are filled with lead the average internal density is reduced to 16.1. Even this density is quite satisfactory in view of the saving in cost due to use of lead instead of mercury. The latter, however, itself is cheaper than the tungsten metal. By use of a special mold it will even be possible to dispense with the steel housing when using the lead-tungsten aggregate.

The filling material for the carrier shown in Fig. 1 costs about $130. Even at that, the cost of the carrier is far less than the best price that can be obtained if the carrier were made by powder metallurgy. The advantage of using a W-Hg filling of 17.2 average density is best realized by considering that 1 in. of this aggregate is equivalent to 1.5 in. of lead and that the Table shows that a half inch of added lead doubles the allowed shipping time. The safe shown in Fig. 1 has a sphere diameter of

Table of Allowable Hours in Transit of Radium Sources Protected with Various Lead Thicknesses.
(Railway Express Agency, Inc. Regulations.)

Milligrams of Radium	Allowed Transit Time (Hours) for Lead Thickness. 1	1.5	2.0	2.5	3.0	3.5	4.0
100	11	22	44	85	170	—	—
200	—	11	22	43	86	172	—
300	—	—	14	28	56	112	225
400	—	—	11	22	44	88	172
500	—	—	—	17	34	68	136
600	—	—	—	14	28	56	112

6 in. and a total weight of about 70 lbs. and wall equivalent to 3-¾ in. of lead. It is equivalent to a similar lead safe having a total diameter of 7¾ in. and weighing around 100 lbs. With it, it is possible to make an express shipment of a 500-mg. unit for 100 hrs.

There will be little point in constructing carrier safes of high density material for radium preparations less than 250 mg. in strength. For these requisite lead containers will not weigh much and are more cheaply constructed. When the strength of the radium source becomes a half gram or more, and the required shipping time long, the advantage of weight and bulk saved by use of high density materials becomes more and more pronounced.

Acknowledgment

The author is indebted to Doctors R. H. Canfield of the Naval Torpedo Station, Newport, R. I. and F. M. Walters of the Naval Research Laboratory for helpful discussion of the problem.

Reference

(1) C. J. Smithells, *Nature*, Vol. 139, 1937, pp. 470-491.

A Letter to the Editor

Conventions in Canada

To the Editor:

In the May 9 issue of *Printers' Ink Weekly*, on page 81, there appears an item of considerable importance at the present time, affecting as it does the relations between the United States and Canada. The item is reproduced here for your information.

> "Several hundred citizens of the United States crossed over into Canada last week to attend the convention of the International Affiliation of Sales and Advertising Clubs at Toronto. Their passage over the line was merely a detail, just as it always has been. It was just as easy and just as pleasant as was their return to the States. We mention this as a dramatic refutation of the ugly reports—evidently emanating from or inspired by the United States branches of Herr Goebbels' lie factory—that American citizens were being subjected to indignities and difficulties when they attempted to visit Canada. So widespread has been this wild-eyed fake that any number of Americans have actually been afraid to visit Canada! In thus disproving it by personal experience, the American advertising people from the Great Lakes section have performed a real service to both countries."

I am bringing this to your attention in the hope that you will see fit to make some suitable editorial comment on this point. The wider the truth can be spread, the better for us all. If this lie about the difficulty of passing to and fro across the border were to be believed, it would naturally affect attendance at gatherings such as that of the National Industrial Advertisers Association, which we are planning for Sept. 17 to 19, at the Royal York Hotel, Toronto.

Chairman,
Publicity Committee,
Toronto Conference, N.I.A.A.

T. S. Glover

SOME CREEP PROPERTIES OF

16 Cr—13 Ni—3 Per Cent Mo Steel

by H. D. NEWELL

Chief Metallurgist, Babcock & Wilcox Tube Co., Beaver Falls, Pa.

In our November, 1939, issue we published an article—"Creep of Some Chromium-Molybdenum Steels"—by Mr. Newell. It was based on a co-operative investigation of three companies on the effect of increasing the molybdenum content on the creep strength of the 4 to 6 Cr - 0.50 per cent Mo steel.

The present article is an adaptation from a series of reports of the Babcock & Wilcox Tube Co. of an extensive investigation of a 16 Cr-13 Ni-3 per cent Mo as to its creep and other properties.

The creep value of certain steels is highly important in applications at high temperatures—such steels must withstand severe treatment.—The Editors.

THE ADDITION OF MOLYBDENUM to 18 Cr—8 Ni steel was originally made for improved corrosion resistance, especially in sulphite paper mills and in chemical process work, notably with acetic acid. The addition of the desired amount of molybdenum, about 3 per cent, to the regular composition of 18 Cr—9 per cent Ni, with maxima of 0.75 Si, 0.60 Mn, 0.07 C, and 0.03 per cent each P and S, produces delta ferrite in the structure. Where the carbon is held at the low level usually desired for corrosion resistance use, the molybdenum addition, with its strong ferritizing effect, throws the structure outside the austenitic range. The structure of such an alloy is duplex, as Fig. 1 shows.

Material of this duplex structure does not hot work well, rupture takes place through the weaker ferrite areas. Such material is particularly unsuited for piercing into seamless tubing. For this reason the alloy, although it is still sometimes referred to in the literature as "18-8 Mo" is, in general, actually produced with a composition nearer to 16 Cr, 13 Ni, 3 per cent Mo, the chromium having been reduced and the nickel increased to produce a fully austenitic structure.

More recently, the alloy has been made available in seamless tube form in two analysis ranges corresponding to American Iron and Steel Institute type numbers 316 and 317 nominal composition: 16-18 Cr, 14 Ni max., 2-3 Mo and 18-20 Cr, 14 Ni max., 3 to 4 Mo. The latter is generally employed where maximum resistance to pitting corrosion in aqueous solutions is desired.

Besides its good resistance to corrosion, the 16-13-3 alloy has very useful high-temperature properties, and, as tubes for high temperature oil cracking operations and certain polymerization and alkylation processes, has met with favor. It resists oxidation under continuous service up to at least 1600 deg. F.

In developing the alloy for tubing for use at high temperature, it has been necessary to evaluate the effect of variations in carbon and in manganese upon the behavior of the alloy in hot piercing at 2000 to 2200 deg., in the range of service temperatures, i.e., up to 1600 deg. F. and at ordinary temperatures.

In the initial work, a laboratory induction furnace heat containing 0.11 C, 0.34 Si, 0.51 Mn, 16.50 Cr, 13.36 Ni, and 2.73 per cent Mo, cast into 4 by 4-in. ingots, forged to 1 in. round, was used. The material as rolled showed a slightly banded, completely austenitic structure, of medium fine grain with fine carbides distributed through the matrix and at the grain boundaries. As-rolled specimens were subjected to creep tests and the creep specimens were then tested in tension and in impact at room temperature on sub-size bars. Some of the results follow:

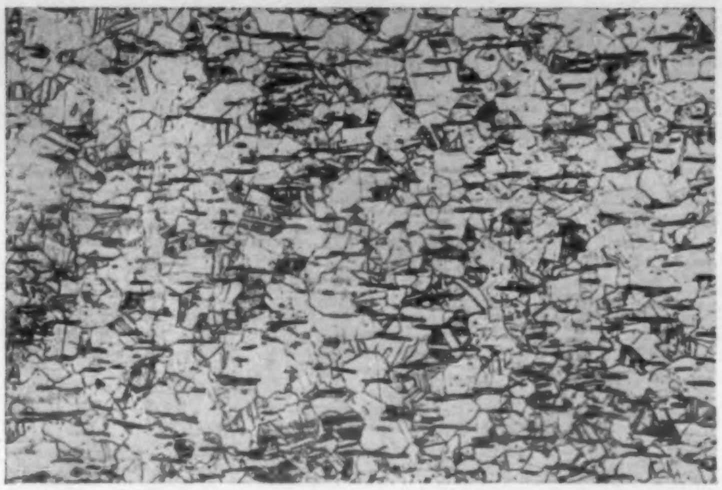


Fig. 1. Standard 18-8 Mo alloy "as forged" showing stringers of delta constituent (black). Etchant: Aqua regia. 100X.

Temperature of creep test, deg. F.	1,200	1,350
Load in creep test, lbs. per sq. in.	10,000	4,500
Time in creep test hrs.	1,057	1,241
Average creep rate, per cent in 100,000 hrs.	1.4	1.65
Room temperature properties after creep. (Specimen 0.400 in. diam., 1.6 in. gage length)		
Tensile strength, lbs. per sq. in.	97,700	102,700
Yield strength, lbs. per sq. in.	50,000	62,300
Elong.—per cent in 1.6 in. ...	37.5	28.7
Red. of area, per cent	53.3	46.7
Hardness, Rockwell B	89.4	91
Impact—45 deg. V notch, bar 0.30 x 0.30 in. ft. lbs.	22	18
Impact keyhole notch, breaking section 0.178 by 0.30 in., ft. lbs.	8.5	7.5

The material was thus indicated to have very good creep resistance and good toughness after creep.

Commercial material was then obtained from 7-ton basic electric heats made by the Allegheny-Ludlum Steel Corp., cast in 12 by 12-in. ingots, and hot-rolled to 1-in. round of three compositions:

	A	*B*	*C*
C	0.074	0.096	0.11
Si	0.35	0.45	0.26
Mn	0.36	1.32	1.00
S	0.013	—	—
P	0.010	—	—
Cr	16.79	16.74	17.03
Ni	13.84	14.16	14.60
Mo	2.66	2.65	2.56

Room temperature properties, after heating 45 min. at 1975 deg. and air cooling, were:

	A	*A* 1725 deg.	*B*	*C*
Tensile, lbs. per sq. in.	82,500	90,150	87,000	88,300
Yield, lbs. per sq. in.	31,500	45,000	35,000	35,750
Prop. Limit	22,750	—	27,500	26,250
Elong., per cent	68.5	49.0	57.5	62.5
Red. of area, per cent	83.5	65.5	77.8	75.7
Brinell	149	156	153	153

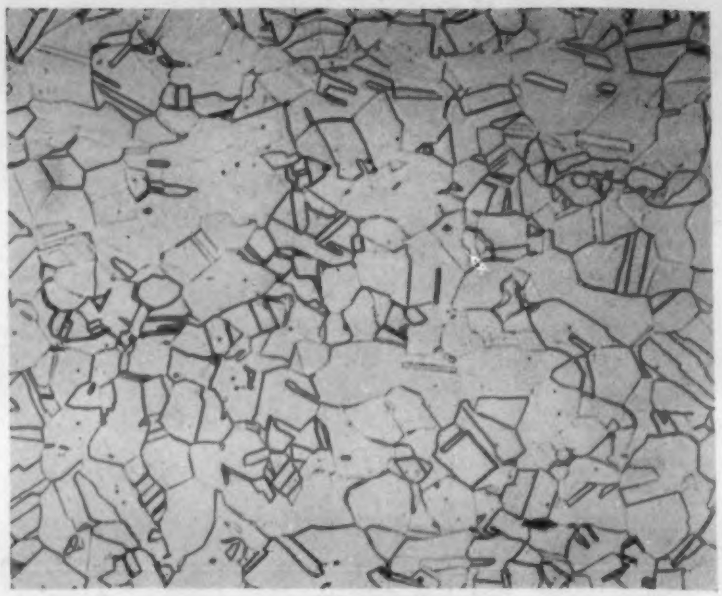


Figure 2

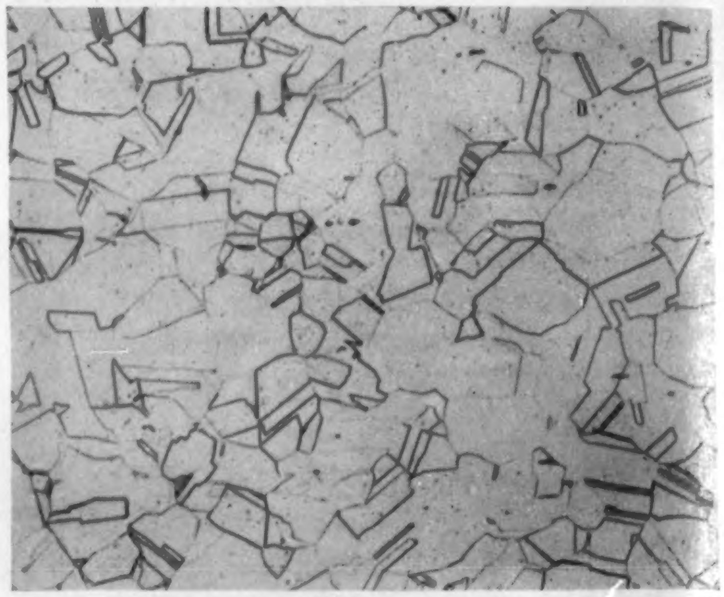


Figure 3

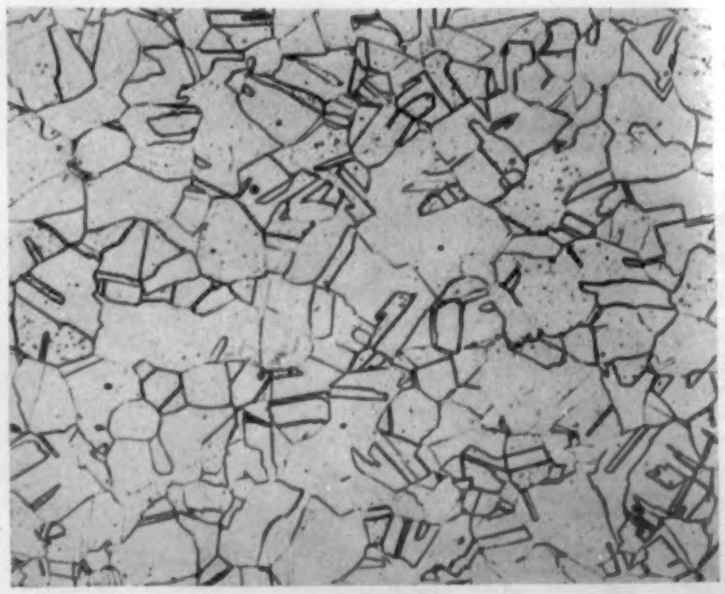


Figure 4

Figs. 2, 3 and 4. Air cooled from 1975 deg. F. Etchant: Aqua regia. 100X. (Heats 47294, 44146 and 48695 respectively.)

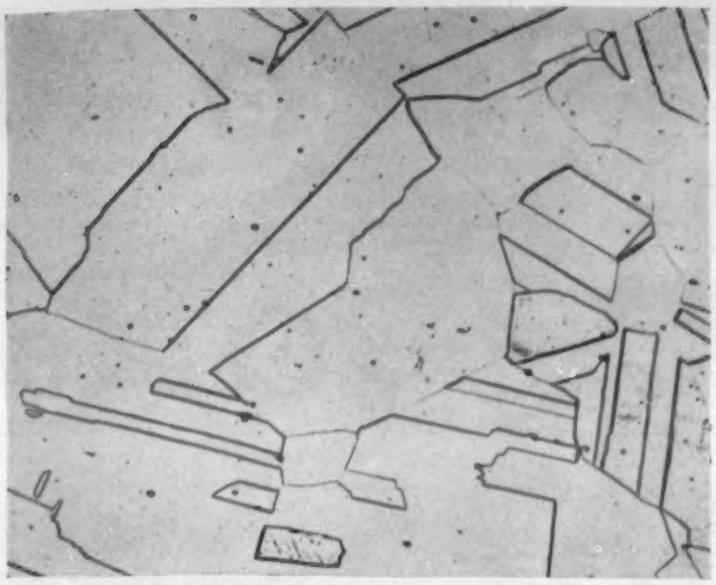


Fig. 5. The grain behavior of Steel A. Water-quenched from 2200 deg. F. Etchant: Aqua regia. 100X. (Heat 47294.)

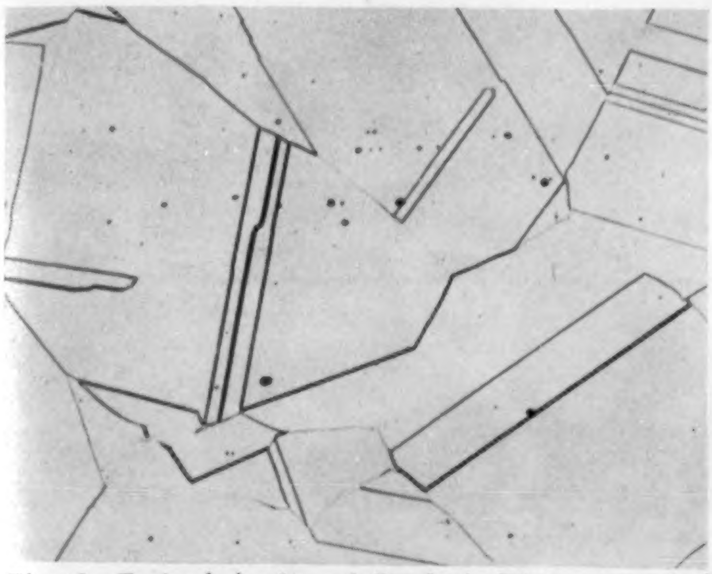


Fig. 6. Grain behavior of Steel A. Water-quenched from 2300 deg. F. Etchant: Aqua regia. 100X. (Heat 47294.)

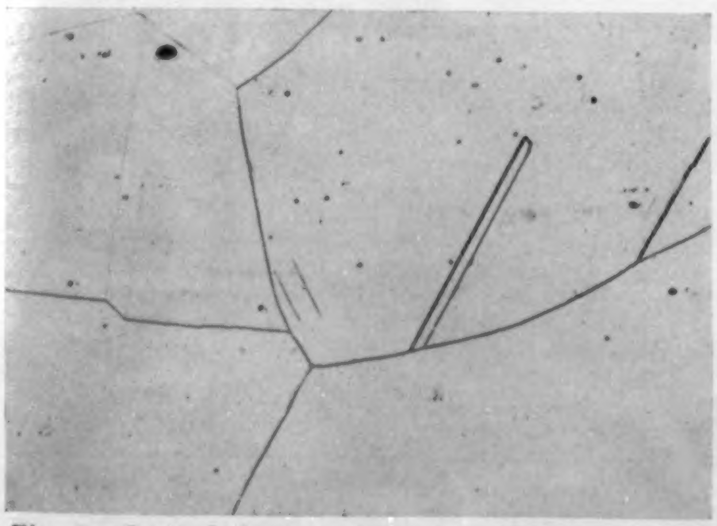


Fig. 7. Grain behavior of Steel A. Water-quenched from 2400 deg. F. Etchant: Aqua regia. 100X. (Heat 47294.)

The structures are shown in Figs. 2, 3 and 4. The grain growth behavior of Steel A is shown in Figs. 5, 6 and 7. The short-time high temperature properties, determined at an extension of 0.017 in. per min. up to the yield, 0.053 in. per min. above the yield, on material air cooled from 1975 deg. were determined over the range 800 to 2300 deg. F. The results are plotted in Figs. 10 to 13. Data for Steel A, heated 1 hr. at 1725 deg. and air cooled are also shown up to 1600 deg. F.

The specimens (1975° air cooled) after testing at elevated temperatures, are shown in Fig. 14. These data show, for the steels heated at 1975 deg. and air cooled, a ductility valley around 1200 deg. F., which, however, is absent in the low carbon Steel A when air cooled from 1725 deg. F.

The behavior of Steel A, air cooled from 1725 deg. in short-time high temperature tensile tests, as traced by a recording extensometer is shown in Fig. 15. Yielding at 1100 deg. F. is by a rapidly recurring succession of slips, not noted at 1200 deg. and above, less notable and of lower frequency at 1000 and 900 deg., and only slightly discernible at 800 and 600 deg. The behavior at 1100 deg. doubtless represents carbide precipitation during the test in particles of critical size for keying. This was not accompanied by the separation of ferrite, since the specimens showed no sign of magnetism. Neither did any of the specimens of Fig. 14 show magnetism.

From the plots of properties and from Fig. 14 it will be seen that ductility at hot working temperatures does not increase with reduction in carbon, instead it increases with manganese. This beneficial effect of manganese has been corroborated by much experience in hot-working the alloy. For tube steel, manganese is now held around the 1.60 per cent level, i.e., above the amount present in this series, even in Steel B.

Fig. 13 shows that the higher manganese steels have much better ductility in the hot-working range 2000 to 2200 F. As a hypothesis, it is suggested that the poorer working qualities of the low manganese steel are due to precipitation at the grain boundaries of a complex submicroscopic oxide of chromium, since hot workability is improved by addition of a considerable amount of manganese, or of small amounts of aluminum or zirconium. Such additions would tend toward the reduction of, or the prevention of the formation of, the postulated chromium oxide.

The precipitation of such a compound is, of course, a separate and distinct phenomenon from that of the carbide separation at 1100 to 1200 deg. F.

Since the preliminary study of the creep properties of the experimental heat indicated these to be of special interest, a more extensive creep study was made of commercial Steel A. Prior to the creep tests the specimens were heated to 1725 deg. F. for

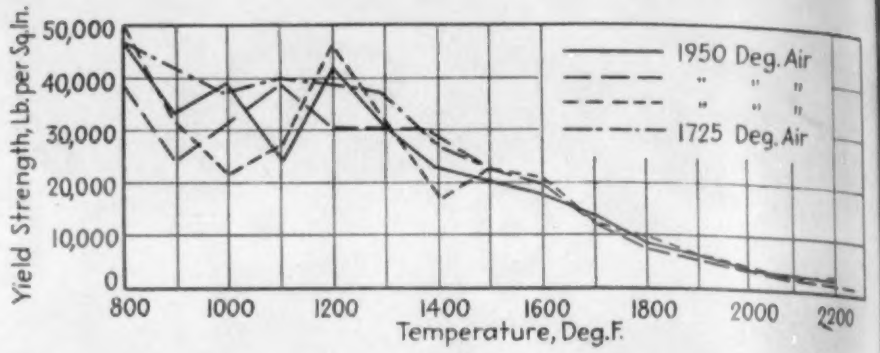
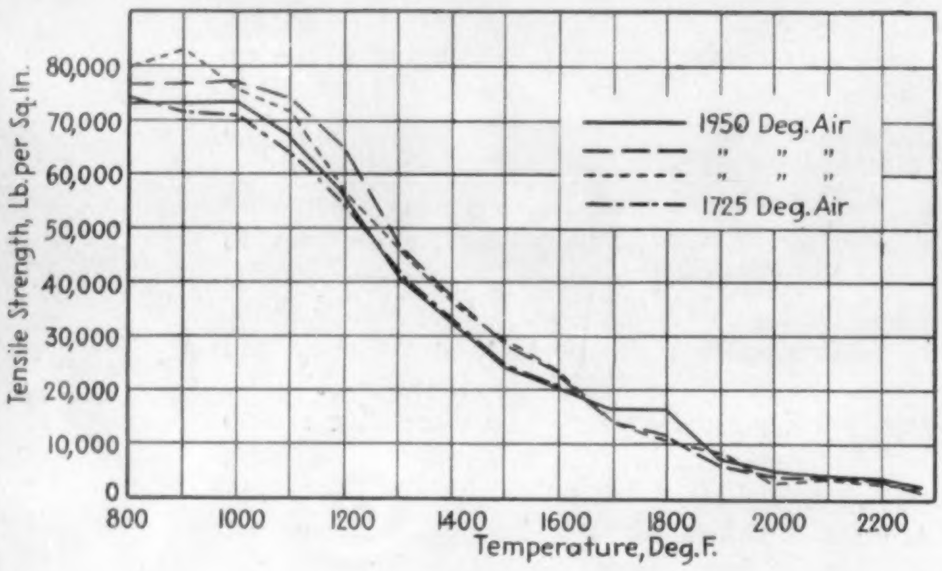


Fig. 11. Yield strengths of Steels A, B and C at various temperatures.

Fig. 10. Tensile strength of Steels A. B and C at various temperatures.



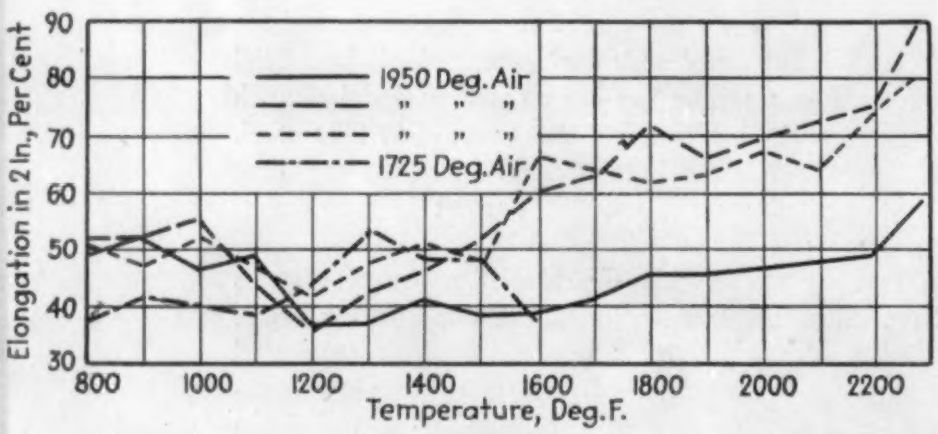
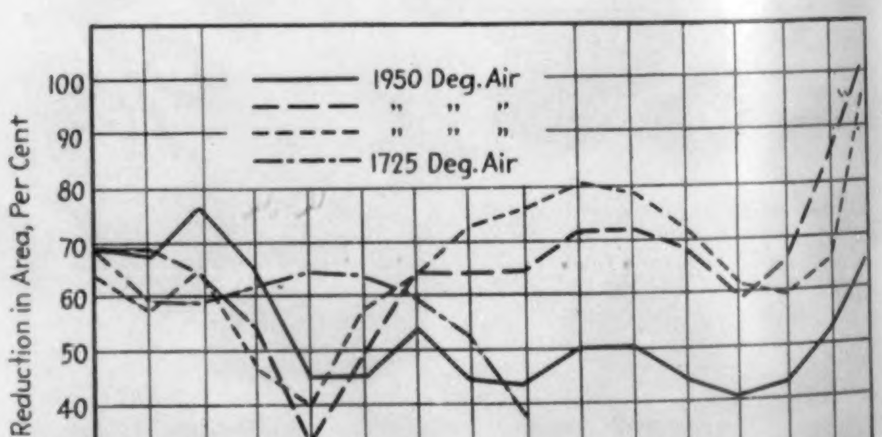


Fig. 12. Elongation in 2 in. of Steels A, B and C at various temperatures.

Fig. 13. Reduction of area of Steels A, B and C at various temperatures.



1 hr. and air cooled. The room temperature and short-time high temperature tensile properties of the material in this condition have been given above. The initial structure is shown in Figs. 16 and 17.

The creep data are given in Table I. From these data the log-log graph of Fig. 18 is plotted. In Table II, the creep properties of Steel A are compared with those of 18 and 8 and 25-20. The molybdenum addition is probably responsible for some of the good high temperature strength. These creep data for 16-13-3 should be conservative, since the specimens used were in a rather fine-grained condition, and the carbon content was low.

A few overload tests to rupture were made on Steel A, as follows:

Load lbs. per sq. in.	*Temp. deg. F.*	*Time to fracture hrs.*	*Elong. per cent at fracture*
9,500	1350	1010	15.0
40,000	1000	1055	5.4
19,000	1200	1555	21.0

Even under these excessive loads, there was ductility at rupture, especially at the higher temperatures.

The better creep behavior of the preliminary heat with 0.11 per cent C over that of Steel A, with 0.074 per cent C, made it desirable to study the suitability of the higher carbon grade for elevated temperature use.

Steels A, B, and C, in 9-in. long by 1-in. diam. pieces, were heat treated in two ways: (1) 1 hr. at 1725 deg., air cooled, or (2) 1 hr. at 1950 deg., air cooled.

Standard Charpy drilled keyhole notch specimens were prepared from the 6 lots, heated at 1100, 1200, 1300 and 1400 deg. F. for 100, 500, 1000 and 1500 hrs. After these exposures to prolonged heating, the Charpy values and the Rockwell B hardnesses were determined. The results are shown in Figs. 18 and 19. No temperature or time of heating used reduced the impact resistance to less than 38 ft.-lbs., nor raised the hardness to more than 98 Rockwell B. Carbide precipitation varies with the carbon content, the initial treatment and the grain size, but as time of heating is prolonged the structure and properties of any one steel tend to become alike, irrespective of initial grain size or of which heat treatment was applied. It will suffice to show

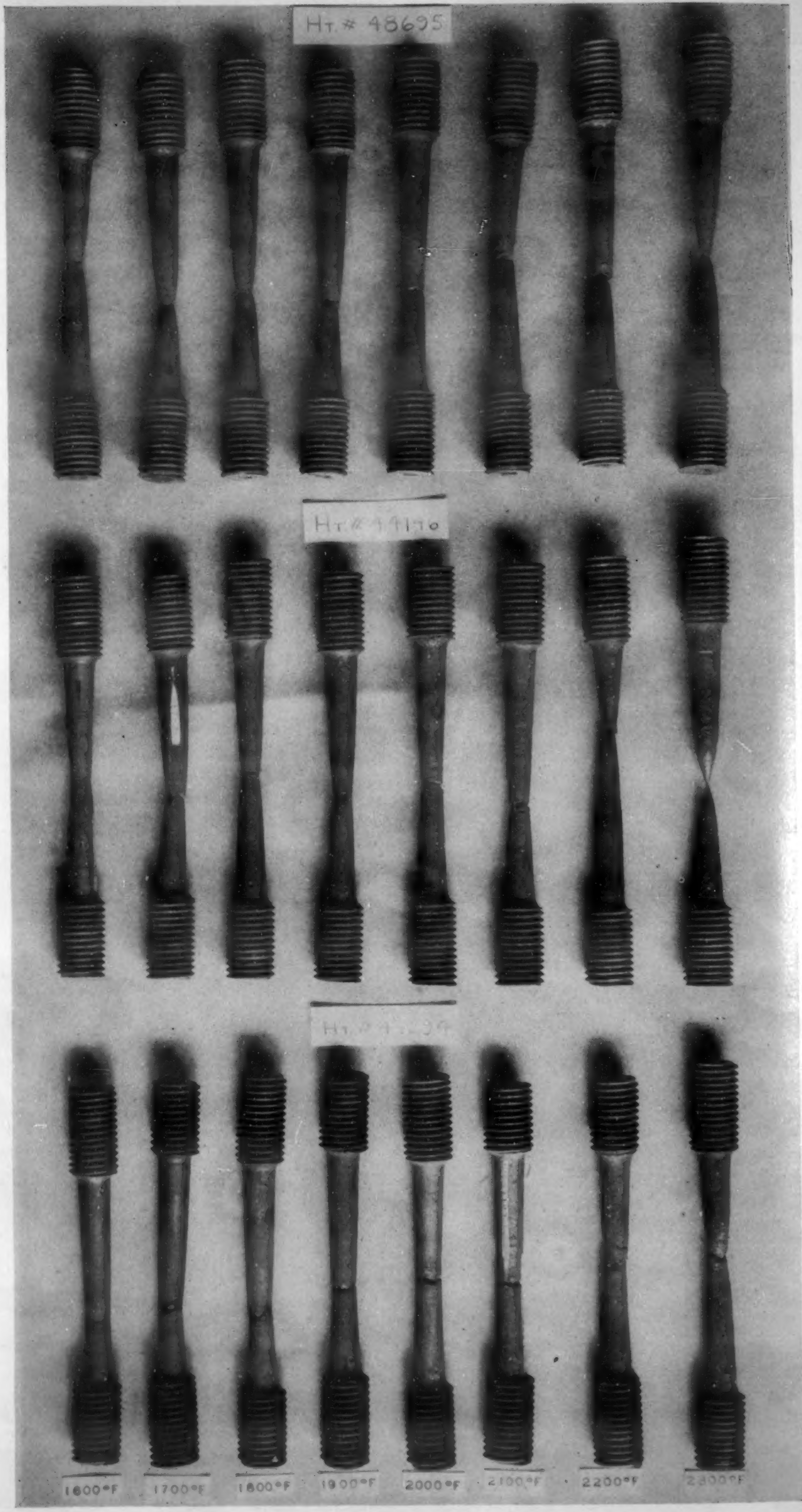
Table II—Comparison of Creep Stress Values

Rate Per 1000 Hrs., Per Cent	1000 Deg. F.	1200 Deg. F.	1350 Deg. F.	1500 Deg. F.
18 Per Cent Cr—8 Per Cent Ni (low carbon)				
0.01	11500	4250	1600	....
0.10	18300	6600	2500	....
16 Per Cent Cr—13 Per Cent Ni—3 Per Cent Mo				
0.01	14800	5000	2500	930
0.10	22800	8200	4200	1840
25 Per Cent Cr—20 Per Cent Ni				
0.01	.....	5400	2800	800
0.10	.....	7400	3300	1100

Table I—Creep Rates—16-13-3 Alloy

Spec. No.	Temp., Deg. F.	Load, Lbs. per Sq. In.	Interval, Hrs.	Rate Per Cent Per Hr.	Rate Per Cent Per 100,000 Hr.	Total Elong., In per In.
233-16	1000	15000	0/500	0.000021	2.1	
			500/1000	0.000021	2.1	
			1000/2000	0.000010	1.0	
			2000/3000	0.000011	1.1	0.0011
233-8	1000	25000	0/500	0.00075	75.0	
			500/1000	0.00043	43.0	
			1000/2000	0.00027	27.0	
			2000/3000	0.000165	16.5	
			3000/4000	0.000165	16.5	0.0153
233-5	1000	40000	0/500	0.00422	422.0	
			500/1000	0.00590	590.0	0.0540
		(Specimen broke at 1055 hrs.)				
233-15	1200	4500	0/500	0.000031	3.1	
			500/1000	0.000012	1.2	
			1000/1340	0.000012	1.2	0.00063
233-A	1200	6000	500/1000	0.000038	3.8	
			500/1500	0.000032	3.2	
			1000/1500	0.000028	2.8	0.00099
233-11	1200	7000	0/500	0.000114	11.4	
			500/1000	0.000074	7.4	
			1000/2000	0.000032	3.2	
			2000/3000	0.000028	2.8	
			3000/3360	0.000028	2.8	0.00218
3-9	1200	8500	0/500	0.00022	22.0	
			500/1000	0.000144	14.4	
			1000/1860	0.000114	11.4	0.0038
33-B	1200	10000	500/1000	0.000375	37.5	
			500/1500	0.000337	33.7	
			1000/1500	0.000296	29.6	0.00658
233-4	1200	19000	0/500	0.01100	1110.0	
			500/1000	0.00980	980.0	
			1000/1500	0.01630	1630.0 (increasing)	0.15
233-C	1350	3000	500/1000	0.000055	5.5	
			500/1500	0.000039	3.9	
			1000/1500	0.000030	3.0	0.001
233-D	1350	4500	500/1000	0.000106	10.6	
			500/1500	0.000096	9.6	
			1000/1500	0.000090	9.0	0.00254
233-10	1350	6000	0/500	0.00064	64.0	
			500/1000	0.00042	42.0	
			1000/2000	0.00043	43.0	
			2000/2730	0.00057	57.0	0.015
233-6	1350	9500	0/500	0.01070	1070.0	
			500/1000	0.01440	1440.0	
		(1010 hrs.—broke—20 per cent total el.)				
233-1	1500	1000	0/500	0.000014	1.4	
			500/1000	0.000035	3.5	
			1000/2000	0.000014	1.4	
			2000/2470	0.000013	1.3	0.00077
233-12	1500	2000	0/500	0.000136	13.6	
			500/1000	0.000134	13.4	0.00228
233-2	1500	3000	0/500	0.00117	117.0	
			500/900	0.00044	44.0	error
			900/1224	0.00035	35.0	error
			1000/2000	0.00400	400.0	0.040

Fig. 14. Specimens of A, B and C (left to right) after testing at elevated temperatures.



the changes in structure of Steel C, air cooled from 1950 deg. F., after 1500 hrs. at the various temperatures, as is done in Figs. 20, 21, 22, and 23 since these have the most marked carbide precipitation.

A study was made by the Crucible Steel Co. of America on the hardness at room temperature, after heating, and the impact (Charpy V notch) resistance at elevated temperatures, after sojourn at elevated temperatures, of 19 Cr, 9 Ni, 3 per cent Mo and 17 Cr, 13 Ni, 3 per cent Mo, both with 0.06 per cent C. Their data, which show the superior toughness of the latter, are given in Tables III and IV.

It is appreciated that the 0.11 per cent C alloy would have increased susceptibility toward aqueous corroding agents after long continued exposure to temperatures in the 1100 to 1400 deg. F. range. Experience shows, however, that corrosion of this type is not encountered in the usual cracking or other processes used on oils and hydrocarbon gases providing condensation of moisture does not take place on external surfaces of tubes during inoperative periods. Hence it appears that the creep strength of the 0.11 per cent C alloy may be utilized in equipment for such processes if proper precautions are taken which would consist of removing sulphate deposits from tube surfaces and then oiling during shutdown. If this procedure is impractical, it would appear desirable to use 0.07 per cent maximum carbon alloy sacrificing some creep strength to gain lessened susceptibility to corrosion due to carbide precipitation effects.

A preferred form of heat treatment for high temperature application consists of heating the cold worked metal at the recrystallization temperature to

Fig. 15. Stress-strain diagrams at elevated temperatures of the 16-13-3 alloy.

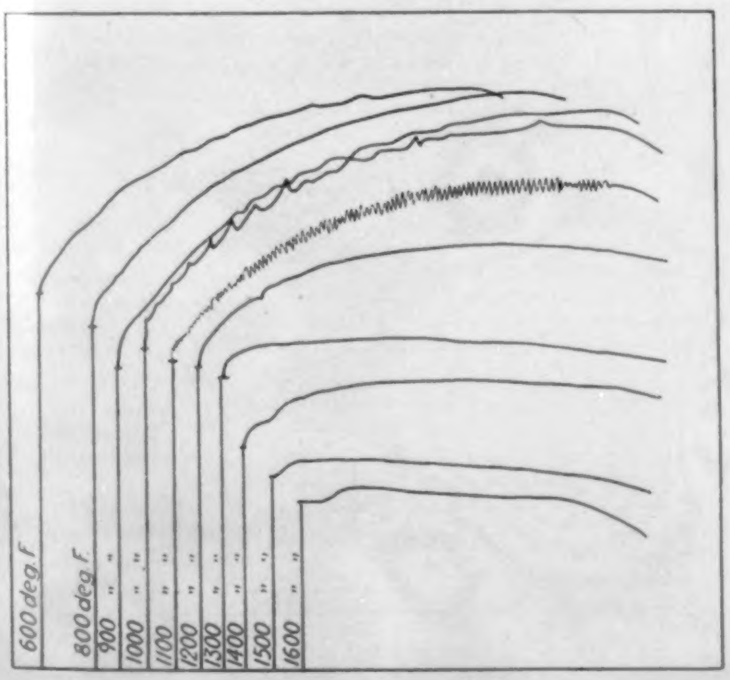


Table III.—Notched Impact Toughness and Hardness of KA-2 S Mo and Stainless 16-13-3 Type (Crucible Steel Co. of America)

Material:

⅝-in. square bars hammered from 30 lb. ingots. Test pieces machined from bars after heat treatment. Bars held at 1900 deg. F. for 20 min. prior to quenching.

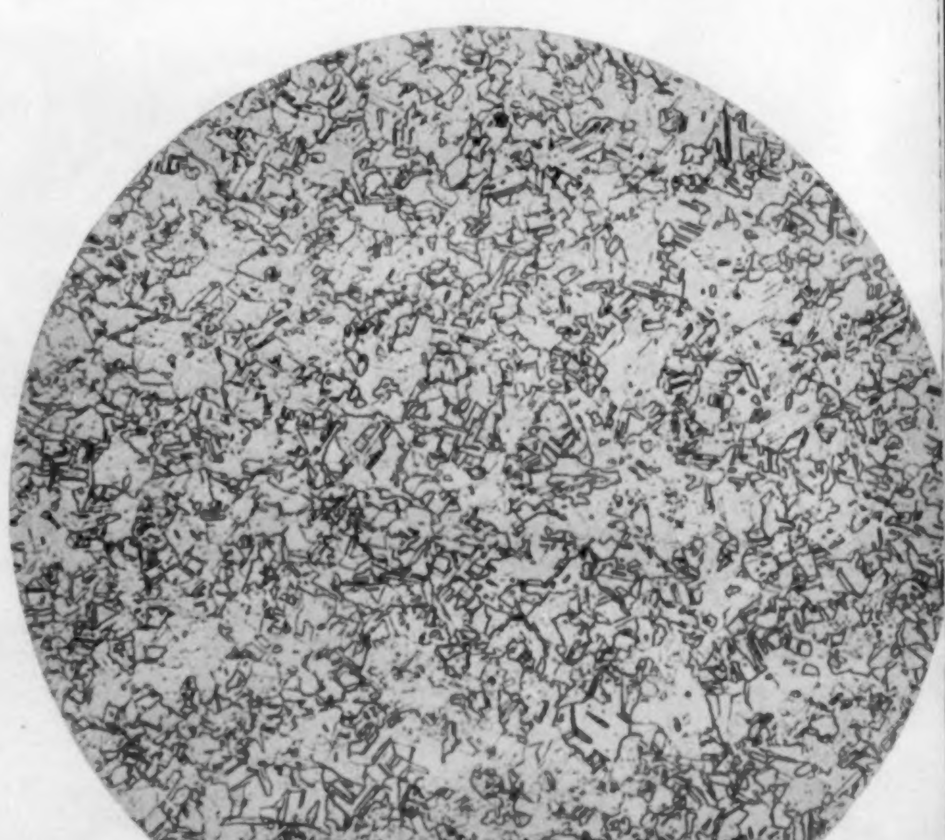
Analyses:

Type	C	Mn	Si	Ni	Cr	Mo
KA-2S Mo	0.06	0.55	0.62	8.71	19.89	2.82
16-13-3	0.06	0.57	0.54	13.03	16.83	2.79

Rockwell "B" Hardness:

No. of Hrs. at 1350 deg. F.	Heat Treatment	Rockwell "B" Hardness KA-2S Mo	Rockwell "B" Hardness 16-13-3
None	As forged	101	98
None	Water quenched from 1900° F.	93	80
210	As forged	102	92
210	Water quenched from 1900° F.	96	79
900	As forged	104	94
900	Water quenched from 1900° F.	97	83

Fig. 16. Microstructure of 1-in. rod of 16-13-3 alloy annealed for creep testing. Etchant: Chrome-regia. 100X.



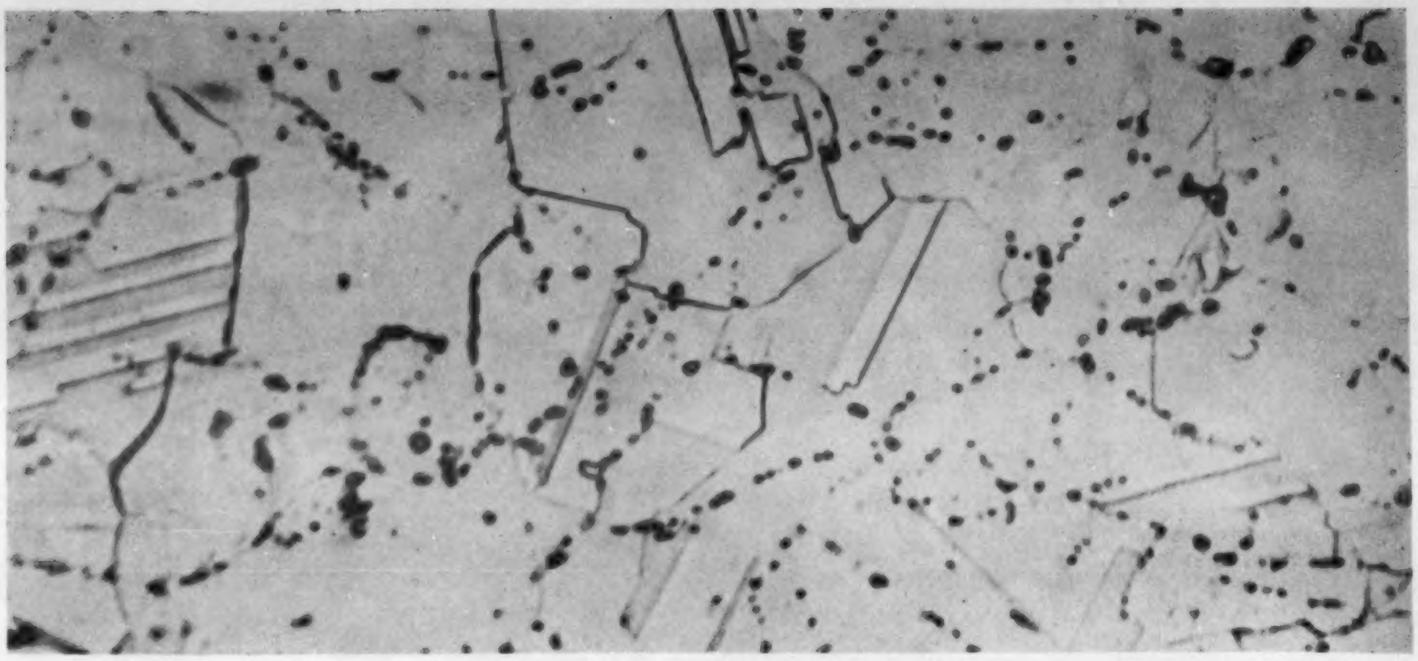


Fig. 17. Same as Fig. 16 but 2000X.

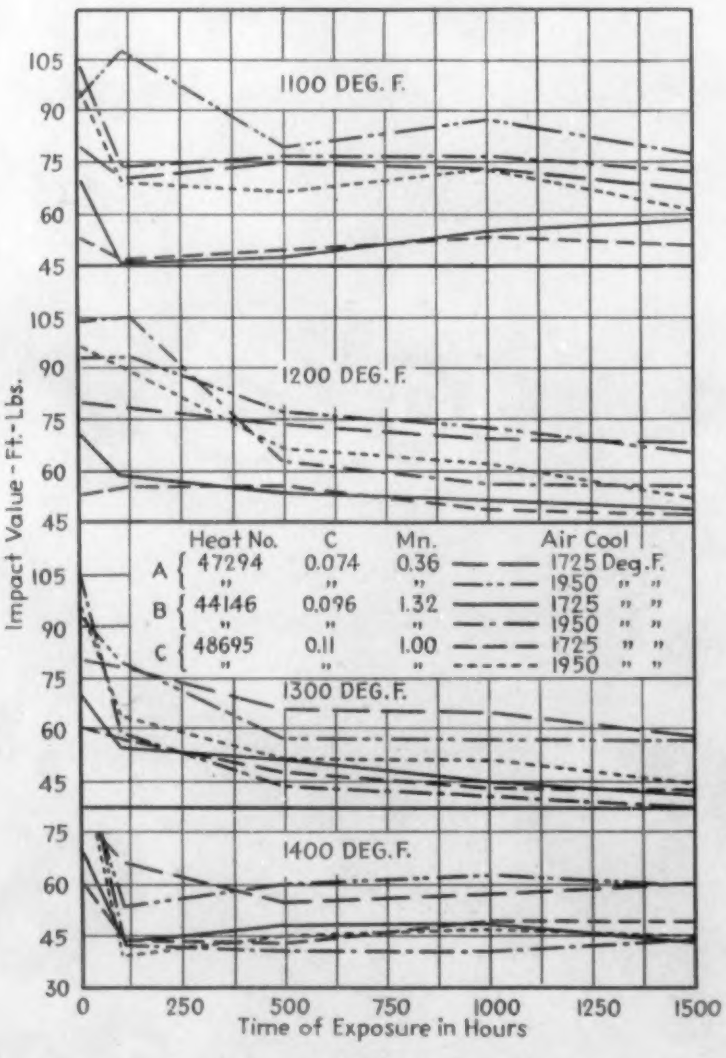


Fig. 18. Impact values of Steels A, B and C.

obtain a fine grain and to precipitate some portion of the carbide in coarse harmless form. Such a treatment will improve resistance to intercrystalline corrosion at ordinary temperature and give best high temperature ductility under stress. Such a treatment is practical as most tubing of the alloy is processed by cold drawing.

A preferred form of heat treatment for high temperature application consists of heating the cold worked metal at the recrystallization temperature to obtain a fine grain and to precipitate some portion of the carbide in coarse harmless form. Such a treatment will improve resistance to intercrystalline corrosion at ordinary temperature and give best high temperature ductility under stress. Such a treatment is practical as most tubing of the alloy is processed by cold drawing.

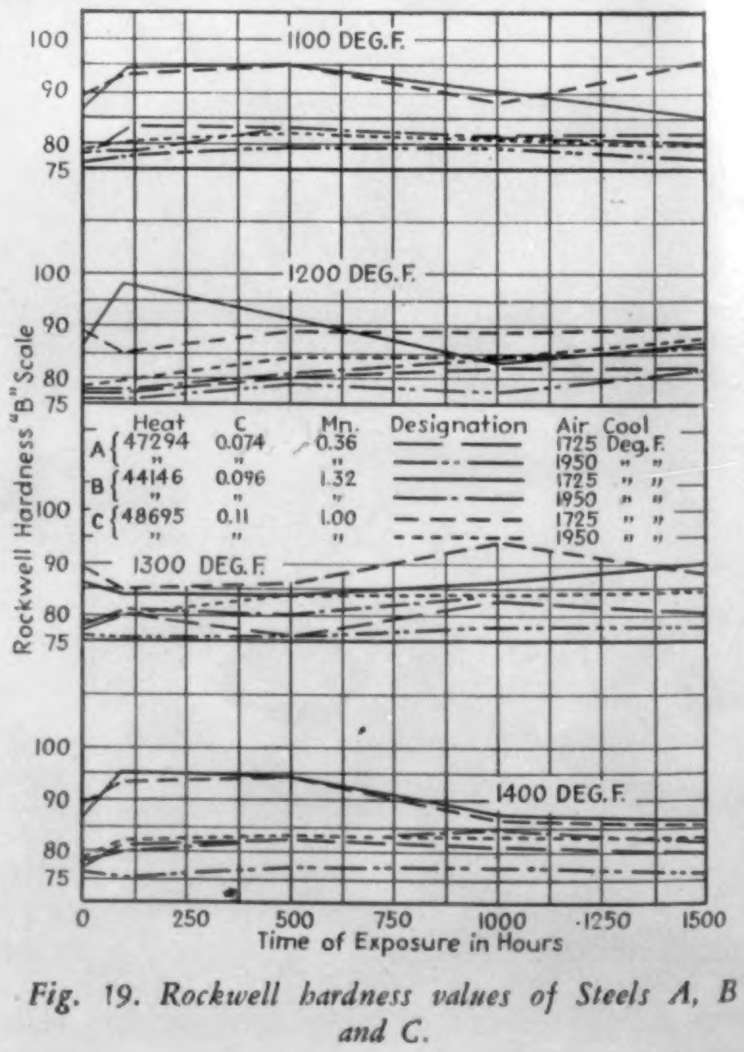
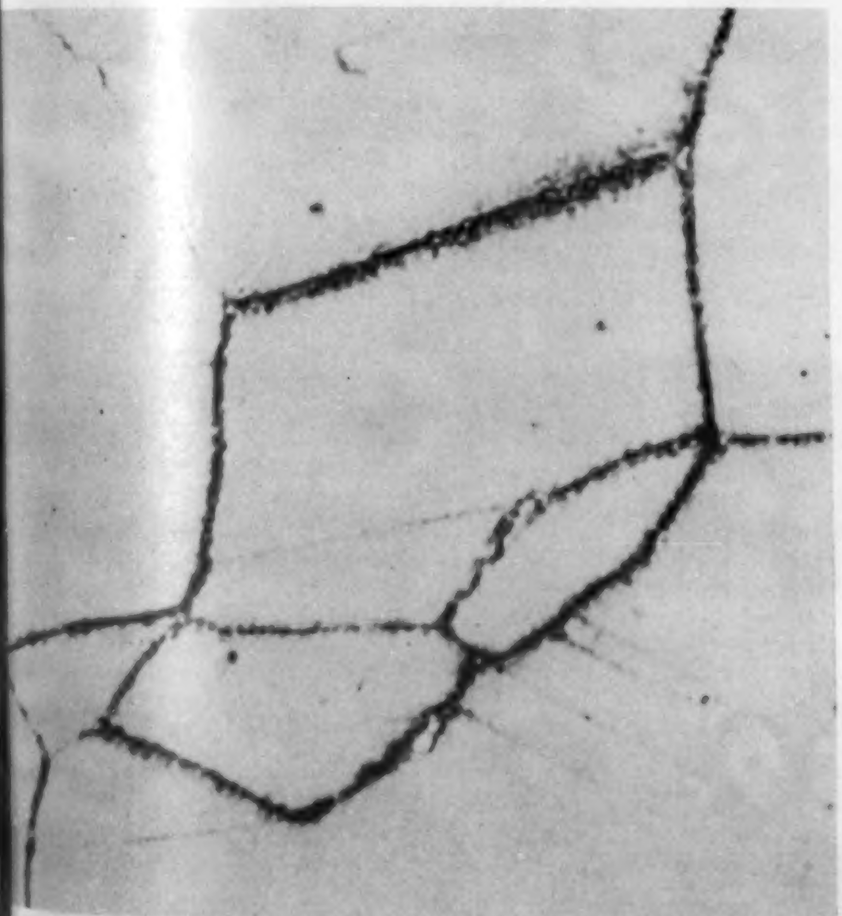


Fig. 19. Rockwell hardness values of Steels A, B and C.

Table IV.—Charpy Impact Tests (Standard Vee Notch) (Crucible Steel Co. of America)

Temp. of Test	Heat Treatment	Ft.-Lbs. Impact KA-2S	Mo	16 Cr-13 Ni-	3 Mo
Room	As forged	80		86	78
Room	Water quenched from 1900° F.	127	133	114	150
1000°F.	As forged	62		82	102
1000°F.	Water quenched from 1900°F.	108	114	141	157
1200°F.	As forged	99		104	104
1200°F.	Water quenched from 1900°F.	135	116	133	139
1350°F.	As forged	80	78	62	82
1350°F.	Water quenched from 1900°F.	127	108	139	137
Room	As forged; 210 hrs. at 1350°F.	11		51	63
Room	Water quenched from 1900°F.; 210 hrs. at 1350°F...........	23	23	77	82
1000°F.	As forged; 210 hrs. at 1350°F.	11		78	82
1000°F.	Water quenched from 1900°F.; 210 hrs. at 1350°F...........	25	28	84	88
1200°F.	As forged; 210 hrs. at 1350°F.	19		71	78
1200°F.	Water quenched from 1900°F.; 210 hrs. at 1350°F...........	31	30	108	108
1350°F.	As forged 210 hrs. at 1350°F.	17	16	94	80
1350°F.	Water quenched from 1900°F.; 210 hrs. at 1350°F...........	30	36	106	108
Room	As forged; 900 hrs. at 1350°F.	6	6	42	46
Room	Water quenched from 1900°F.; 900 hrs. at 1350°F...........	16	14	58	51
1000°F.	As forged; 900 hrs. at 1350°F.	8	8	58	63
1000°F.	Water quenched from 1900°F.; 900 hrs. at 1350°F...........	17	19	80	69
1200°F.	As forged; 900 hrs. at 1350°F.	10	11	71	75
1200°F.	Water quenched from 1900°F.; 900 hrs. at 1350°F...........	24	25	84	96
1350°F.	As forged; 900 hrs. at 1350°F.	14	11	62	69
1350°F.	Water quenched from 1900°F.; 900 hrs. at 1350°F...........	24	25	75	67

Fig. 20. Heat 48695. Air-cooled from 1950 deg. F. Held at 1100 deg. F. for 1500 hrs. Etchant: Aqua regia. 2000X.



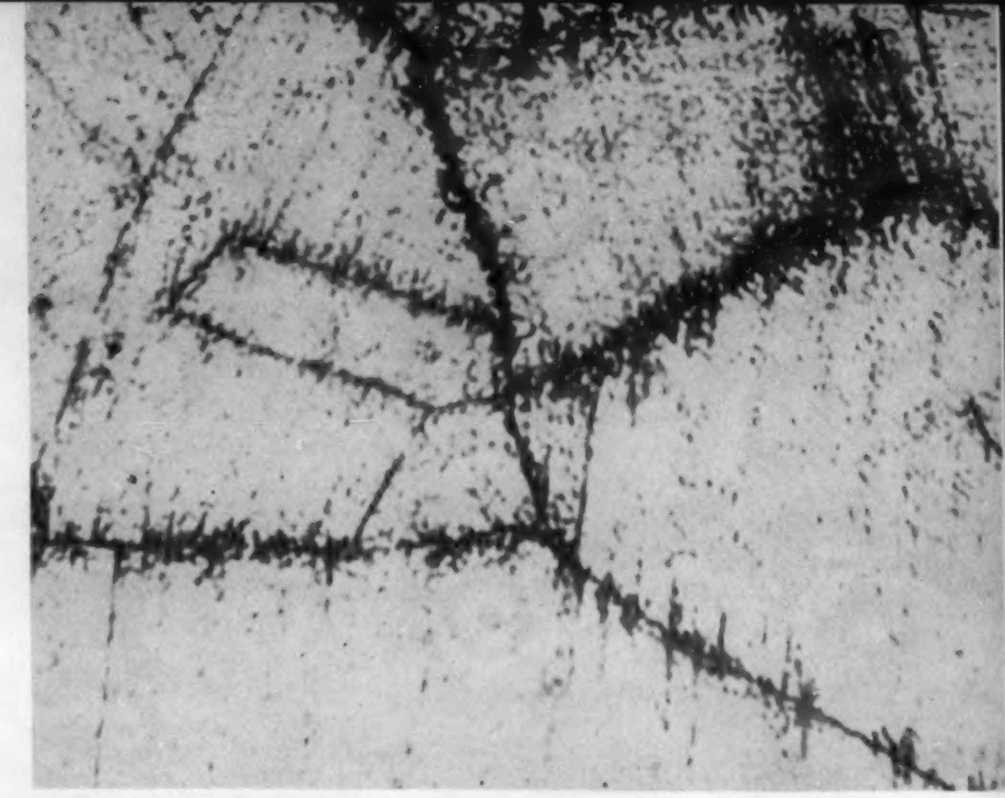


Fig. 21. Heat 48695. Air-cooled from 1950 deg. F. Held at 1200 deg. F. for 1500 hrs. Etchant: Aqua regia. 2000X.

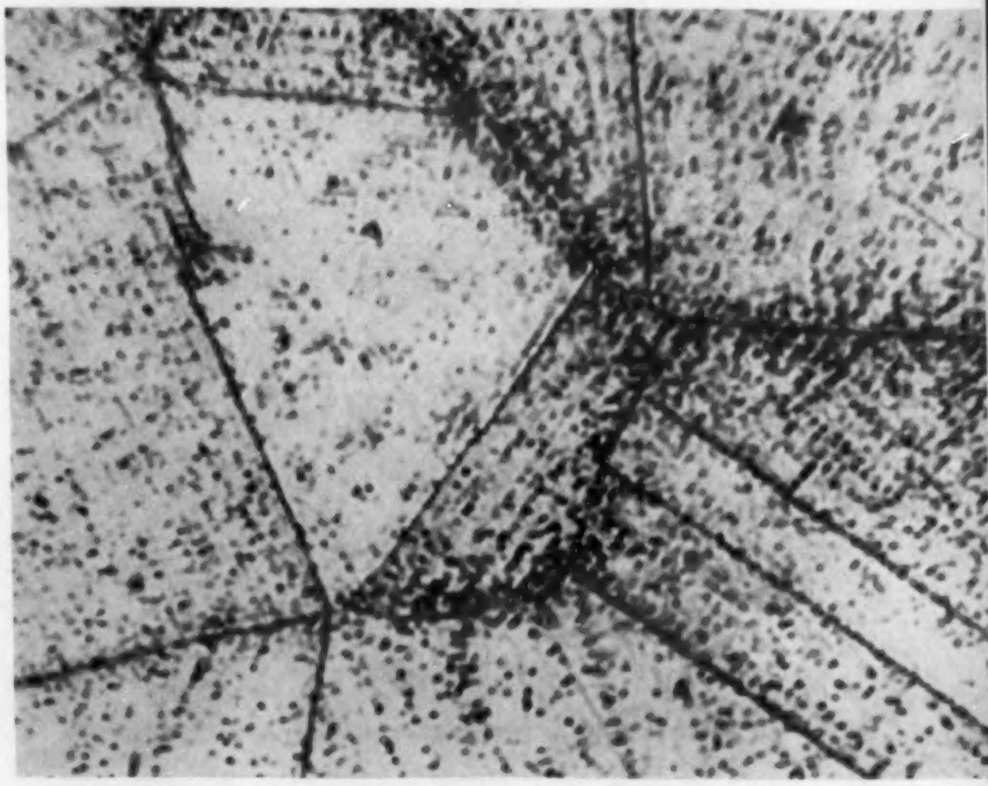
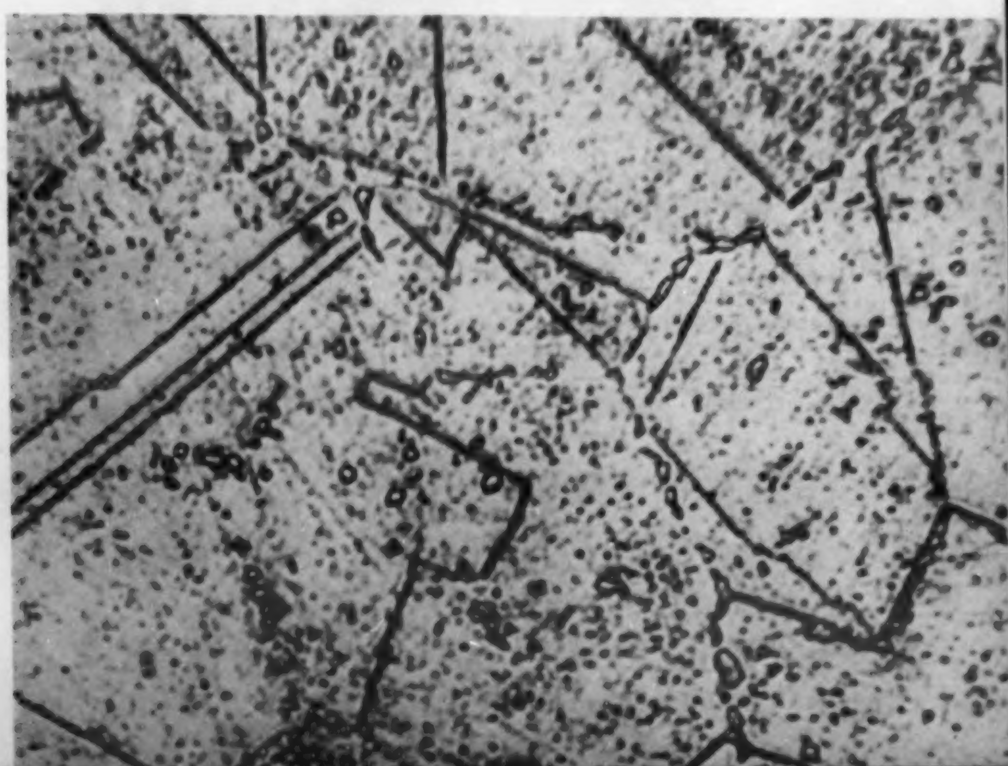


Fig. 22. Heat 48695. Air cooled from 1950 deg. F. Held at 1300 deg. F. for 1500 hrs. Etchant: Aqua regia. 2000X.

Fig. 23. Heat 48695. Air cooled from 1950 deg. F. Held a. 1400 deg. F. for 1500 hrs. Etchant: Aqua regia. 2000X.



Editorials *(Continued from page 149)*

industry, which are constantly increasing ingot and steel castings capacity and output.

We do not feel that the expansion suggested is necessary. While non-defense demands must be curtailed, it is believed that normal expansion will meet present and future demands.—E. F. C.

Providing another 10 million tons to meet the expected increased national income with opportunities for increased consumer spending on non-defense articles is not a good way to prevent inflation.

Read the editorial in the *Sat. Eve. Post* for July 5!—H. W. G.

Society Chapters

As editors we are constantly bombarded with announcements of scheduled meetings of local sections of the technical societies. These statements are often alluring, promising a highly interesting coffee talk, an industrial movie, followed by a more or less attractive technical address. Some of the latter are highly educational, some are not, judged by those we have attended.

The bombardment in recent years has become analogous to a "blitzkrieg"—so much so that our curiosity was aroused as to just how many sources of such artillery fire there were. So we canvassed nine of the technical societies related to the metal and alloy industries. The number of chapters in these societies, as of June 1, is as follows:

American Society for Metals	51
American Society of Tool Engineers	43
American Welding Society	41
American Institute of Mining and Metallurgical Engineers	34
American Electroplaters' Society	31
Society of Automotive Engineers	22
American Foundrymen's Association	21
American Society for Testing Materials	9
The Electrochemical Society	7
Total	259

This total of 259 local chapters or sections of the nine societies is beyond our expectations! While some of these are not so active as others, the sum total is forbidding if one feels he has to take in every such meeting in his locality to keep up with developments. The picture as a whole is a dreary one if a person feels a sense of duty to keep in touch with two or three societies in his own local district.

There is a feeling, quite widespread, that this local chapter business is being overdone—one large society trying to compete with another in numbers and scope. It is described by some as almost approaching a "racket."

While there are, as a whole, too many such local subdivisions, the net benefit is without doubt impressive. It is incumbent on those interested in the metal industries to watch carefully the projected schedules because otherwise he may miss a really good lecture. Regular attendance at the local meetings of two or three societies without picking out only those that promise some real information is likely to be a waste of valuable time.—E. F. C.

Induction-Hardened Aircraft Cylinders—A Correction

In the article "Induction-Hardened Cylinder Bores," published in our June issue, the implication is made in the first paragraph on page 719 that a large aircraft engine manufacturer had abandoned the use of nitrided cylinders in favor of Budd-hardened cylinders. Actually no aircraft engine manufacturer has made a "switch" of this nature, the large-scale application of induction-hardening cited in the article being in a *new* type of aviation engine.

—The Editors.

letters TO THE EDITOR

One Good Way to Save Aluminum

To the Editor: Any expedient which will result in saving tens, if not hundreds of thousands, of pounds of aluminum monthly when this metal is sorely needed is deserving of the most careful consideration. This is especially true when the same expedient results in a much more rapid production as well as in many economies in skilled labor and in machining and which, at the same time, can be made to yield a product which is better in every respect than that now in use or contemplated for use.

Use of Permanent Molds

The expedient in this case involves the production of permanent mold castings in place of certain sand cast-

ings now required or shortly to be needed in large quantities. Such castings are necessary for aircraft and for tank parts and probably also for other equipment of vital importance in the rearmament program. In certain important cases, at least, no redesign will be required. In other cases some insignificant changes may be needed. Where there is time for redesign, still further economies can be secured for the reason that permanent mold castings have significant physical properties some 25 per cent better than sand castings.

To effect the change, according to highly experienced authority, will work no considerable hardship on the aluminum sand casting industry, as it already has or soon will have as much work as it can hope to turn out with the experienced labor required for molding in sand. Such labor necessitates years of training and is already reported as almost impossible to secure. In addition, much equipment for molding and a very large foundry space will be necessary if the castings in question are to be produced in sand molds. Moreover, a great deal of labor and much machining is required on aluminum sand casting, whereas relatively little is needed on the permanent mold type (including the "semi-permanent" mold type, which is here referred to as being in the same category).

As an example of what can be done in the saving of aluminum, our informant, who has had wide experience in both types of aluminum casting—sand and permanent mold—mentions one casting some 30 in. in diameter which weighs approximately 66 lbs. when produced in sand and from which 16 lbs. of metal, is cut away in machining. As against this, the permanent mold casting, which is better in all respects, weighs 56 lbs. as produced and requires the removal of only 6 lbs. of metal in machining. This is said to be typical of several castings, a few of which have already been converted from sand to permanent mold form, as well as to many more now about to enter quantity production, most of them to be required in lots of many thousands.

Supply of Permanent Molds

When asked if the permanent mold casting producers could handle the added requirements, our informant stated that this has been given careful consideration and that the extra production can be taken on readily. It will be necessary, of course, to provide the permanent molds, which are high grade alloy iron castings and require careful machining, but there are said to be sources through which these molds can be provided. Much of the mold production can be done by tool shops accustomed to making dies for die castings and molds for plastics. Where essential, this work can be given a priority basis. Curtailment in normal retooling activities in the automotive industry may also provide considerable capacity for making permanent molds.

It is not contended, of course, that all or even a large part of the aluminum castings now or about to be produced in sand molds can be converted to production in permanent molds. If the conversion is to be made, it must be confined, of course, to castings suited for permanent mold production and it is well known that many designs of aluminum sand castings cannot be reproduced at all in permanent or semi-permanent molds. Those to be so converted naturally are suited to such production, and there are many such.

Although the foregoing explanation may appear obvious to those well acquainted with permanent mold castings and their possibilities, it is unfortunately true that the engineers and metallurgists of many companies know so little about permanent mold castings that they are hardly given a thought. These engineers turn instinctively to sand castings, with which they are more or less familiar or may be impelled to do so by the specifications imposed by Army or other Government authorities who also lack experience with permanent mold castings. In normal times, this procedure is logical enough, because then the quantities of castings required are not often sufficient to justify the investment in permanent molds. Today, quite the reverse is true, in the type of castings in question. Quantities are large and the savings on several other scores, together with the better qualities of the permanent mold aluminum casting, result in both economies and in a more suitable product.

Several producers of light equipment commonly made in quantities, such as the automotive and some electrical manufacturers, are well aware of the above situation and their experience with permanent mold castings has already impelled them to turn to this type wherever it is suited for the job or at least in many such cases. But other manufacturers accustomed to making heavier equipment in smaller quantities, who do not have the quantity production experience, naturally incline toward the sand casting and some are already reported to be finding it hard to secure such castings as rapidly as wanted. Even when the sand castings are available, the large amount of machine work involved means delays in production and demands much equipment and labor. This is not a reflection upon anybody, but the natural result of taking on jobs somewhat outside the normal experience of the organizations concerned.

Advice Regarding Permanent Molds

To those who have little knowledge of the permanent mold aluminum casting, a few words of caution may be in order. The successful production of permanent mold castings is not the simple problem which it may appear to be at first thought. It requires skill and experience which relatively few companies possess and they are the companies which should be consulted. Few makers of aluminum sand castings know much about permanent mold work; how to design the molds or to use them as they must be used for good results. But the experienced makers of permanent mold castings naturally understand thoroughly what is required and, according to our informant, either have or can quickly provide the extra capacity needed and can train the extra men to do the work. An intelligent laborer can be converted into a good hand at making permanent mold castings within 6 mos. or less. The skill required to design and construct molds as well as to maintain them (an important consideration) can be spread quite easily to care for the extra production necessary.

Although Washington authorities have been apprised of the foregoing facts and may take steps to put them before those who should profit by them in due course, to do so is only one of thousands of jobs needing attention. But the men who do the actual manufacturing are not in Washington and it is they who should take the matter referred to in hand as, indeed, some who understand the facts fully have done already. It is hoped that the foregoing may point the way to others who can follow the procedure indicated with profit to all concerned. Whatever approval is necessary from Washington must be secured, of course, but with Washington urging more speed in armament production it is not likely to stand in the way of anything which will bring it about and which, at the same time, will save no small amount of aluminum for other important applications.

HERBERT CHASE

Forest Hills, N. Y.

Zinc and Aluminum Die Castings

To the Editor: Most designers are now fully aware of all the advantages afforded them by "die casting" both in aluminum and zinc. However, the data often cited have been derived either from special test experiments or from ideal designs.

The first consideration of a part for die casting is the alloy, zinc or aluminum. Comparison of these two alloys, which are most prominently used, has been generally based on weight, price, finish, and design. Inasmuch as the weight per cubic inch of zinc is approximately 2½ times that of aluminum, these two alloys would compare favorably should the price per pound be in the same proportion; although die casting of aluminum involves slightly higher cost due to lesser production per day. However, in the past years, the cost of aluminum alloys has been reduced while zinc has risen steadily, thereby placing aluminum in a more favorable position. Aluminum die casting has recently received a great impetus from the National Defense Program because of the weight factor.

Zinc Alloys

These die castings are made in alloys covered by A.S.T.M. specifications; the most popular ones being No. 21, No. 23 and No. 25. For the past few years No. 23 (about 4% Cu, 0.04% Mg, bal. Zn) has been used most extensively due to its extreme ductility and elongation. Recently, there has been a decided trend toward No. 25 (about 4% Al, 1% Cu, 0.03% Mg, bal. Zn) which has the highest tensile strength (47,000 lbs. per sq. in.), though at a slight decrease in elongation. This alloy results in a better surface in a die casting where finish is important, as when a casting is to be plated. Inasmuch as plating is frequently of greater cost than the casting itself, a minimum of buffing is essential to keep the cost down. Where a zinc casting is not for exterior use, it can be left in the original cast state. Some finishing must be done to protect the surface of the casting by either painting, plating, or dipping if used for exterior use. If left in an unfinished condition and exposed to the atmosphere, zinc oxide will form in a few months, depending upon use. However, this oxide does not affect the strength characteristics of the die casting materially.

There have been many new finishes placed on the market in past years which considerably improve the appearance of aluminum, such as chrome plating, anodizing, alumiliting, etc. Designing of aluminum parts should give prime consideration to the factor of tapers. Designers should see how much taper each wall, diameter, etc., the parts can possibly stand instead of requesting minimum taper as is the usual practice now. Aluminum has an affinity for, i.e., adheres to, steel in a liquid state, thereby making pulling of cores and ejection of the casting from dies difficult. In many cases the addition of proper tapers, which do not affect the design, have increased production 50 per cent resulting in a lower piece price to the user. All cores should have the maximum taper and then be drilled to size where necessary, regardless of diameter. Cores less than 0.100 in. in diameter should not be cast, inasmuch as they would quickly burn away or break, and in most cases should be spotted. While castings with wall thicknesses of 0.050 in. have been made successfully, these are exceptions and would depend a great deal upon the design of the piece. Most aluminum pieces should have walls of 0.090 in.

Aluminum Alloys

The most frequently used aluminum alloy consists of about 91 Al, 4 Cu, 5 per cent Si (A.S.T.M. B 85-39 T—Alloy VII). An alloy which is now growing in use and which is widely used on government specifications is 89 Al, 11 per cent Si (A.S.T.M. B 85-39 T, Alloy V). Prospective users of aluminum die castings should not request special alloys unless absolutely necessary.

Special alloys raise the cost of the casting considerably as the standard alloys must be removed from the die casting machines and replaced with the special mixture, which is costly. It might be well to point out an instance in which the special alloy has raised the price of an article, used in millions, approximately 20 per cent. This item with a weight of approximately 1½ oz. has been made by most of the die casters in America, and due to the user's insistence that the iron content be kept to beneath 0.80 per cent Fe, it has necessitated the making of these castings on a cold chamber die casting machine instead of the conventional gooseneck. Inasmuch as the characteristics in a casting made with 0.80 per cent Fe content and the casting of 1.30 per cent Fe content are practically the same, the insistence of the user on this minimum is foolish and costly. A gooseneck die casting machine, due to the aluminum being kept in a cast iron vessel, would add approximately 0.40 to 0.50 per cent Fe, thus if the specification on the alloy had been increased from 0.80 to 1.30, these castings could have been made at a far greater production speed and lower cost.

In both alloys, both zinc and aluminum, the use of inserts has been growing steadily. Usually it is far more economical to cast the inserts during the casting cycle than it is to ream the diameter and push in a bushing. The average cost of placing a bushing in a die casting mold is usually as low as $3 to $4 per M depending upon piece and design of inserts.

In all castings, particular attention snould be paid to the elimination of sharp corners and generous fillets should be used wherever possible. In all cases, wall sections should be kept as uniform as possible, and where these sections do meet thinner sections, large fillets and judicious ribs facilitate the casting operation.

Great attention in designing new articles for die casting should be paid to parting lines. This is of the greatest importance since it affects not only die cost but piece cost as well as final appearance. Frequently, a casting can be re-designed so that a stepped parting can be straightened and excess metal hollowed out with great savings.

Dies for aluminum die castings in the past have been approximately 20 per cent higher in cost than for zinc die castings inasmuch as the former necessarily have to be made of chromium-vanadium steel and hardened. Recently, due to large quantities, most of the zinc dies have also been made of chromium-vanadium steel and hardened, thereby making the die costs of each metal comparable.

In obtaining estimates from drawings, it is usually well to ask for recommendations and advice. Personal consultation with the die caster before construction of parts has frequently resulted in a better die casting and a saving to the user.

L. P. Held,
Vice-President

Mount Vernon Die Casting Corp.
Mount Vernon, New York

Another expert, commenting on this matter, says that Mr. Held's remarks on fillets, tapers, parting lines and inserts justify reiteration. Also that any discussion of zinc alloys should refer to the paramount necessity of avoiding contamination. Magnesium and lead die castings are both gaining in importance as a result of the Defense Program—magnesium for airplane starters and other parts, lead as a replacement for scarce zinc for automobile trim. Cold chamber die casting machines are coming into increasing use for low iron content aluminum die castings of maximum toughness and density, as well as for brass and magnesium.

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

Metal Conservation

Problems of metal *conservation* are beginning to look as formidable in many ways as problems of defense *production*. In the cases of some metals (*e.g.* aluminum) the two problems have practically merged, increased production and conservation being simultaneously applied to improve the situation. In other instances the conservation of one metal (say tin) may involve increased production for replacement purposes of another (silver, for example). In still other cases (die castings or aluminum cooking utensils) the conservation program with respect to non-defense articles has shaken a whole industry and indicated the need for seeking defense-production uses for equipment and men that will otherwise be idle.

Tin Conservation

In a recent report of the Advisory Committee on Metals and Minerals of the National Research Council to the O.P.M., the tin supply and consumption situation is closely examined and many engineering suggestions made for replacing tin with other metals.

The report, the work of engineers associated with a leading research institute, points out that all-out substitution could replace ¾ of the tin ordinarily used in this country. The suggestion of outstanding interest in the report is that silver may be substituted extensively for tin in solder—a replacement which, when coupled with a reduction in thickness of tin on cans already in effect, would reduce total tin consumption about 25%.

The feasibility of replacing a large amount of tin with a small amount of silver in solders was favorably examined in the article "Tin Plate and Solder from the Strategic Viewpoint" in our November, 1940 issue. As shown in the report to the O.P.M., 40 to 50 lbs. of tin may be replaced with 2.5 to 5 lbs. of silver, and at prevailing prices the cost of the substitute solder is nearly identical with that of the conventional material.

The committee's suggestions were as follows:

(1) Progressively but drastically reduce the amount of tin in solder, being careful to allow time for workers to become skillful in handling the higher-melting substitute solders.

(2) Expand the use of glass containers for beer and certain food products.

(3) Impel an orderly substitution in the can-making industry of thin electrolytic tin plate and of black plate for the usual tin plate.

(4) Restrict the use of new tin for cast or wrought bronze where silicon bronzes and the like are applicable.

(5) Adapt bearing-design in new machines to use lead-base rather than tin-base babbitts, to use thin rather than thick babbitt linings, or to use other than babbitt bearings.

(6) Cut down the amount of tin allowed for solid-tin collapsible tubes and eliminate the use of tin for tinfoil.

(7) Eliminate the use of tin for pewter and in galvanizing.

(8) Watch the use of tin in "tinning" —*i.e.* applying protective coatings to other materials than tin plate.

(9) Acquaint tin users with intimate details of the behavior of substitutes, so that utilization may be prompt, when necessary.

Die Castings

The situation in the die casting industry brought about by metal shortages is reviewed and some possible palliatives presented in a report to the O.P.M. by Harvey A. Anderson, its technical consultant on die castings, summarized herewith.

Because prospective supplies of zinc, aluminum and magnesium are insufficient to take care of this country's defense program plus anticipated civilian demands, most of the large consumers of die casting alloys are voluntarily either curtailing production or introducing substitute materials. For example, limitations of 1942-model passenger car output to 3½ million cars together with simultaneous substitutions will convert to defense use more than 118,000,000 lbs. of zinc and 20,000,000 lbs. of aluminum. Although not all of this represents die castings, the program will remove a large part of the chief market for die castings.

Based on the die casting industry's estimate that less than 15% of its capacity is now engaged in defense production, it appears that either its personnel must be transferred to other defense industries or the die casting industry must secure more defense business to replace the vanishing non-defense production. Such additional business "must be secured . . . by doing an efficient job of salesmanship on the advantages of die castings in effecting savings in materials, machines, man-power and delivery intervals."

In 1940 the production of zinc-base die castings approached 90% of the total die casting tonnage. Furthermore, the majority of the die casting equipment is of the immersed plunger type, as used for making zinc die castings; relatively few producers have gooseneck or cold-chamber type machines as used for producing aluminum, magnesium and brass die castings.

Therefore, if die casting capacity is to be utilized generally in the defense program, it will be necessary either to demonstrate the suitability of zinc alloys for additional defense applications or to convert die casting equipment to make it suitable for the production of aluminum die castings.

Die cast defense products are *generally* made from aluminum and comprise parts for instruments, airframes, airplane engines or ordnance fuse parts. Ordnance officials have indicated the possibility of replacing such aluminum die castings with dense stable zinc die castings, but emphasize that for fuse parts zinc die castings must pass

(MORE NEWS ON PAGE 190)

firing tests under extreme temperatures (—50° F. to + 170° F.) and must be definitely of uniform quality.

Apparently the only zinc die castings suitable for ordnance use are those made with 99.99% zinc and free of lead and tin contamination. A recently approved Army-Navy Aeronautical Spec. on aluminum die castings permits the use of any one of 3 alloys—(a) 5% Si, 4 Cu; (b) 12% Si; (c) 8% Mg. Army Air Corps design instructions do not bar the use of die castings from structural parts, but specify that the calculated stress of a die cast part must not exceed 15 per cent of its ultimate tensile strength.

With the magnitude of the defense program, the total die casting output should be increased rather than diminished if the industry will apply itself aggressively to the problem of selling the defense procurement agencies, the report concludes.

Replacing Galvanized Coatings

In the "tin report" summarized above, the replacement of tin-plate for tin cans be lacquered or otherwise-protected black plate is discussed. Similar substitutes for zinc coatings are being offered, and for at least one of these a claim of superiority over galvanized finishes is made.

According to *Roxalin Flexible Lacquer Co.*, Elizabeth, N. J., "Roxaprene," a corrosion-resistant fast-drying synthetic outlasts galvanized coatings by several hundred per cent in both 2% caustic soda solution and dilute hydrochloric acid solution. It can be applied by dip, spray or roller coat and air dries quickly.

Saving Steel in Shipbuilding

A Maritime Commission report received by the *James F. Lincoln Arc Welding Foundation*, Cleveland, reveals that by the use of welding in place of riveting in the 705-shipbuilding program now underway, over a half-million tons of steel (about 24 million dollars) is being saved.

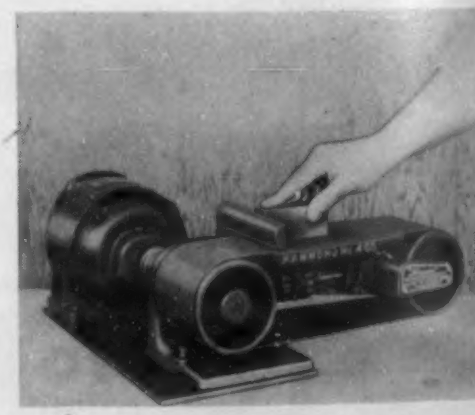
The report states that "the greatest single weight saving advance [in shipbuilding] has been the introduction of welding. This has so replaced riveting that today entire ships are being turned out without a single rivet. . . . Since the ships are that much lighter, an extra half million tons of cargo can be carried by these 705 ships in a trip."

● *The Summerill Tubing Co.*, Bridgeport, Pa., is establishing a series of prizes totaling $600 to be awarded by the American Welding Soc. at its October 1941 meeting, for papers to advance the art of welding aircraft steels including tubing and tubular assemblies.

Versatile Belt Surfacer

A new bench-type belt surfacer for wet or dry buffing, burring, surfacing or polishing a number of different materials—plastics, stainless steel, lead, aluminum, wood, etc.—is now being manufactured by *Hammond Machinery Builders, Inc.*, 1646 Douglas Ave., Kalamazoo, Mich.

Known as the Hammond "400," the new machine is designed to reduce rejects and to facilitate finishing work formerly done by hand. With a suitable belt, the machine may be used for rough work, such



as sprue removal from castings, or flash removal from forgings. With a different type of belt, a very fine polish may be developed on other materials.

Power is furnished either by direct or V-belt drive from a ⅓ h.p. motor operating at 1725 r.p.m. The machine operates in any position between horizontal and vertical, and is very simply adapted to wet surfacing.

New Welding Equipment

New welding equipment designed to meet the increased production demands of the defense program has been developed and introduced by several companies serving our field. During the last month, two manufacturers have announced a series of welders and auxiliaries of various types—arc welders, arc welder trailers and resistance welding contactors.

Aircraft Arc Welders

A new arc welder designed specifically for aircraft fabrication—one that will permit a wider range of amperage for easier welding of aircraft alloys of all thicknesses—has been introduced by *Lincoln Electric Co.*, Cleveland, O.

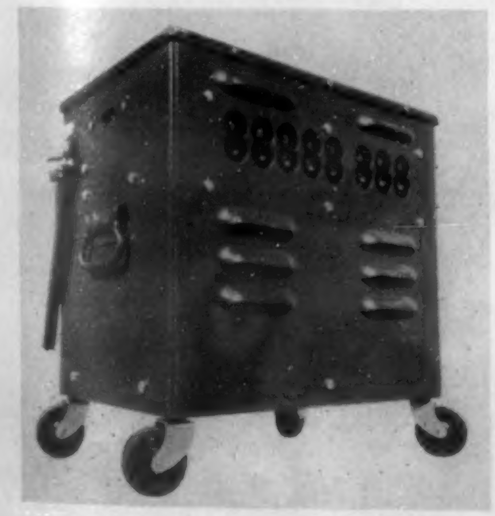
The new unit is called the "Shield-Arc Jr." aircraft welder, features dual continuous control and is available in 150 amp. and 200 amp. grades. Current settings as low as 10 amps. can be obtained, permitting the quality welding of thin gage metals and alloys.

According to the manufacturer, the new aircraft welder in conjunction with Lincoln "Planeweld" Nos. 1 and 2 electrodes is a distinct contribution to the welding of S.A.E. 4130 and X-4130 chromium-moly steels for aircraft construction.

Arc Welder for Light Gages

. For use in welding light gage metal, castings, drive shafts, general maintenance and light production work, a new "Flexarc" welder—Midget Marvel WT-1—is announced by *Westinghouse Electric & Mfg. Co.*, E. Pittsburgh.

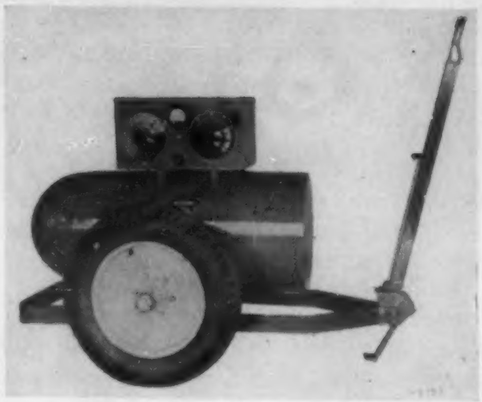
Sensitive adjustment of the welding current over a range from 20 to 140 amps. is provided by 15 steps with correctly proportioned increments between steps. Full load rating is 110 amps. when used on 220-volt, 60-cycle lines. The cost of power consumption is about 5c an hr.



The unit is very compact and weighs 160 lbs. It comes complete with accessories, including the primary cable for hooking up the power lines.

Welding Machine Trailer

A new 2-wheeled light weight pneumatic-



tired trailer for mounting arc welding machines for easy, fast portability is announced by *Lincoln Electric Co.*, Cleveland, O. The new unit is designed for mounting such welders as Lincoln's S.A.E. 200 to 600 amp. AC motor-driven arc welders or type SA 200 special engine-driven arc welders.

The new unit measures 66 in. long, 42 in. wide and 16 in. high, and weighs 282 lbs. It can be used for road towing up to about 30 miles per hr., can be hitched to a factory mule or industrial truck and is easily moved by hand.

Spot Welder Contactor

For use with timing facilities in spot welding, a new electronic welding con-

tactor has been developed by *Westinghouse Electric & Mfg. Co.*, E. Pittsburgh. The new equipment is known as the SW 150 "Weld-O-Trol," and is rated equivalent to a size 2-W mechanical contactor at 220 or 440 volts, 50/60 cycles.

Welding current is handled at extremely high rate of interruption by 2 heavy-duty water-cooled ignitron tubes. The tubes can be removed without disturbing the water connections and a thermostat protects the tubes against damage through failure of the water supply.

The unit is readily adapted for use with heat control and either synchronous or non-synchronous weld timers, including sequencing equipment.

● Accurate and smooth machining of 3 different types of variable-pitch airplane propeller bronze (Ampco Metal No. 18) bushings, complete except for bolt holes, in 2 operations, totalling 18 min., is now being accomplished on high-production turret lathes equipped with tungsten carbide tools, reports *Carboloy Co., Inc.*, Detroit.

New Oven Construction Material

Many present-day ovens and driers consist of a steel casing or housing supported on structural steel with insulation sandwiched between the inner and outer steel facings.

A new type of furnace construction called "Marinite," announced by *Johns-Manville Inc.*, 22 E. 40th St., New York, is a combined structural material and insulation. The use of a non-steel material of this type is said to eliminate the difficulties arising from the high coefficient of expansion of steel and its high heat conductivity.

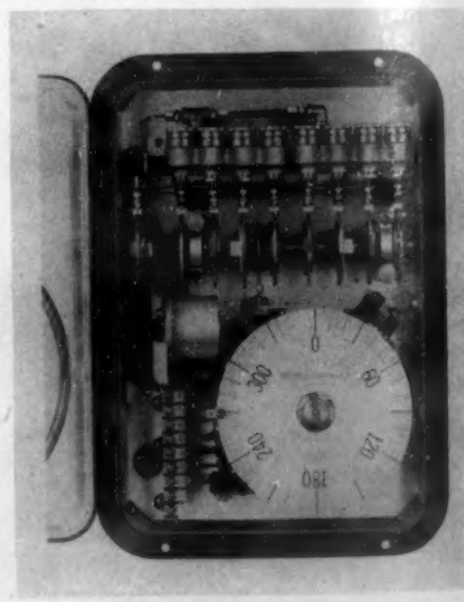
In addition, this new oven construction material can be applied by a carpenter in the same manner as wood. Panels can be fastened together by bolts, for example, so that ovens and dryers so made are entirely portable.

The material itself is a solid homogeneous sheet material made of asbestos fibre with an inorganic binder. It is said to be unaffected by water and corrosion and to be thermally efficient because of the absence of through-metal. The material is strong and relatively light in weight.

Time-Cycle Controller

A new time-cycle controller designed for use on industrial processes where a number of factors must be accurately timed according to a fixed program has been developed by *Bristol Co.*, Waterbury, Conn.

Known as the Model A-118 Impulse-Sequence Cycle Controller, the new unit is of the multiple cam type and operates



by actuating or engaging at exactly the correct time in each cycle the necessary mechanical, electrical or pneumatic devices for automatically carrying out the intended schedule.

In this controller, time measurement and pilot valve operation are handled by separate mechanisms. Timing is accomplished by a Telechron-driven disc on which is printed a 25-in. time scale.

The desired schedule is incorporated into the controller by pushing holes with an ordinary ticket punch on this scale. Discs for new cycles can be easily made.

Cleaning Carburizing Compound

A new, low-cost "Carbo-cleaner"—a carburizer screening machine designed to save time and improve screening efficiency—is announced by *Thurner Engineering Co.,* 809 National Ave., Milwaukee, Wis.

The new machine is intended to replace manual shake-out operations in heat treating shops and departments, and to efficiently remove small particles of scale, dust and ashes that hinder carburizing and shorten the life of carburizing compound.

The unit is compact, being 54 in. high, 46 in. long and 28 in. wide. In operation, the carburizer is automatically fed from a built-in hopper into an inclined rotary screen and is then pushed upward at the rate of 1000 lbs. per hr. over 23½ ft. of screening surface.

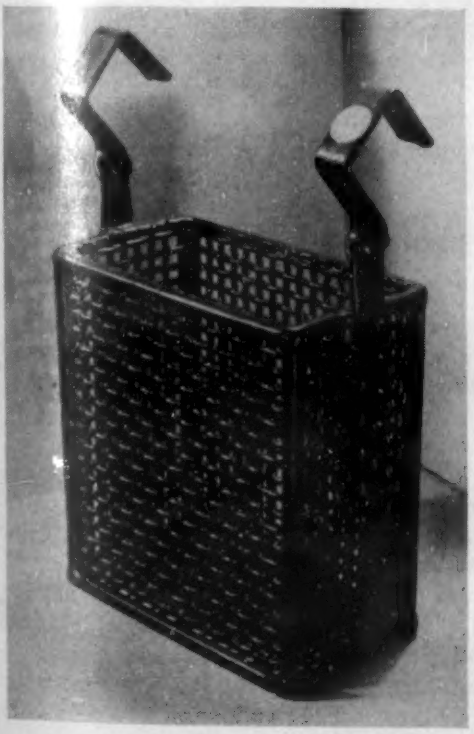
The non-usable material is deposited in a drawer at the bottom of the machine. The reclaimed compound flows out of a spout at the front, aerated and cleaned and ready to use again.

The machine is powered by a 1/6 h.p. motor and V-belt. The screen is removable, making the machine adaptable to all screening purposes.

Anode Scrap Baskets

The present shortage of some metals makes the efficient use of scrap of vital importance to industry as a whole as well as to individual plants. For the electroplating industry, *Hanson-Van Winkle-Munning Co.,* Matawan, N. J. have developed a new type of basket for handling scrap anodes.

The new basket is rubber-covered and is furnished with 2 hooks, allowing it to be



hung on anode rods in both still and barrel tanks. In use a new anode is inserted in the basket and hung on the anode bar; the anode stubs are placed in the basket around the new anode, thus permitting the use and salvage of the scrap metal.

The baskets can be used in solutions at temperatures below 190 deg. F. The inside dimensions of the baskets may be from 9 in. long by 18 in. deep by 4 in. wide, to 20 in. by 40 in. by 4 in.

Spectroscopic Electrode Driller

An electrode driller to prepare carbon or graphite rods for use as electrodes in spectrochemical analysis has been developed by *Jarrel-Ash Co.* (representatives of Adam Hilger, Ltd.) 165 Newbury St., Boston.

The instrument simultaneously faces the end of the rod and drills a cup to receive the sample. Or it can also turn a shoulder on the rod to produce an electrode for the cathode layer method of analysis. It can also point the carbon to serve as an upper electrode.

Diameters from ⅛ to ⅜ in. are handled. The unit does not soil the surroundings with carbon dust, and introduces no chemical contamination in the electrode. It is supplied with a universal motor.

● Integral-bonded alloy-lined plate (such as "Pluramelt") has been approved by the Boiler Code Committee of the American Society of Mechanical Engineers for use in the construction of fusion-welded, unfired pressure vessels, and the list of acceptable "stainless" cladding alloys has been extended to include Types 410, 430, 446, 304, 310, 316, 317, 321 and 347, reports *Allegheny Ludlum Steel Corp.*

● Steel plate, tinplate, brass, copper, various alloys, plywood and plastics can now be supplied coated with sensitized emulsion for direct photographic reproduction, announces *Republic Engineering Products, Inc.*, 480 Lexington Ave., New York. Some of the above can be obtained 1/8-in. or 1/4-in. thicknesses, such as are used for making templates.

● The latest 75-mm. pack howitzers for the Army are being produced at *General Electric Co.'s* Schenectady plant largely on machines previously used for making electric motors for street cars and locomotives.

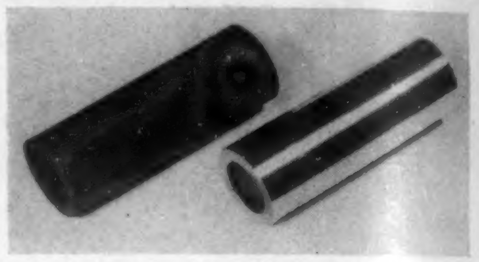
Bright Gas Carburizing

A new type of gas carburizing furnace, said to provide bright gas carburizing without scale, soot or tar formation, and in only a fraction of the time required by other methods, is announced by *Lithium Corp.*, Raymond-Commerce Bldg., Newark, N. J. The new furnace is known as the "Lithcarb" atmosphere furnace, and embodies the use of a "Lithco" (lithium salt) compound.

This compound, according to the manufacturer, neutralizes harmful oxidizing gases that cause scaling and decarburizing in the usual gas carburizing operations and permits the steel being treated to take on carbon continuously (without interference from side reactions), so that the carburizing time is reduced to 1/3 of the time usually necessary.

In the illustration, the part at the left is described as an ordinary gas carburized part after an 8-hr. treatment, which gives a case depth of 0.045 in. The part at the right is an identical steel part after it had been treated for 3 hrs. in the Lithcarb furnace to give a case of the same depth. No sand blasting or other handling operations are said to be necessary for final finishing of Lithcarb-treated parts.

The new furnace and process are claimed to be completely automatic and fool-proof, and to involve no atmosphere adjustments or special training on the part of the operator. A carrier gas generated within



the furnace entrains the vapor evolving continuously from the Lithco compound in a low-cost cartridge refill, the work being bathed in this neutralized carbon-rich atmosphere.

● A new line of "Torflex" bearings with inner walls of a new, thinner, material—plain or graphited bronze-on-steel—which are said to have better shock resistance and low friction coefficient and to be available in a wider range of size and shape on shorter notice than the older cast styles, is announced by *Harris Products Co.*, 5408 Commonwealth Ave., Detroit.

Electric Silver-Soldering Unit

A new electric brazer for brazing with silver solder is announced by *Ideal Commutator Dresser Co.*, 1928 Park Ave., Sycamore, Ill.

The brazer consists of a power unit or transformer and a pair of electric heating pliers. The act of holding the part to be brazed in the pliers closes the secondary circuit and causes the part to heat quickly to brazing temperature, the heat being controlled by an on-and-off foot switch.

The brazer is compact, portable and always ready-to-use. Overall size is 14 in. x 12 in. x 25 in.; the 60-cycle unit weighs 100 lbs., the 25-cycle unit, 150 lbs. The machine operates on 230-volt, 50-60 cycle power supply, or on 440 volts, 25 cycles. the rating is 7.5 kv.-a.

This equipment is said to extend the field of silver-soldering to include many jobs heretofore soft-soldered as well as those ordinarily silver-brazed in other ways. Joints and connections in motors, transformers, leads, terminals, bus bars, auto engines, aircraft engines, carbide tool tips, band saws, etc. are among the possible applications.

Cold-Nosing Artillery Shells

The use of cemented carbide dies for the cold-nosing of 105-mm. shells is interesting not only from the straight-out production and die-life viewpoints, but, in a specific application reported by *Vascoloy-Ramet Corp.*, North Chicago, Ill., for the size of the die itself.

The dies, of tantalum-tungsten carbide, are believed to be the largest cemented

carbide dies ever produced. The work in which they are used is done on conventional vertical mechanical presses, at a production rate of 120 shells per hr. per press.

The shell is held in a fixture on the bed of the press while the die descends and performs the nosing operation. The die itself consists of a tantalum-tungsten carbide insert, the inside of which is finished to the contour of the shell, firmly mounted in a substantial steel casing. It is estimated that each die will nose several million shells.

● The first million-volt X-ray machine for welded pressure vessel inspection—a General Electric X-Ray Corp. unit—has been placed in service at the Barberton plant of *Babcock & Wilcox Co.* for inspecting welds in vessels of thicknesses up to 8 in. A similar unit is being installed by *Combustion Engineering Co., Inc.*, for the same type of application.

Plant Expansions

Plant and organization expansions in all the metal-producing and metal-consuming industries indicate the extent to which industry is plunging into the defense program and presage a continuing rise in production volume.

The Aluminum Co. of America reports that its Vernon (Los Angeles) permanent-mold foundry and forge plant completed in 1938 has been further expanded during the last year, and now includes an extrusion works and a rivet plant. In terms of floor space, this works has been expanded 455% since the start of the war.

Another new Aluminum Co. plant, the Lafayette, Ind. works built in 1938, has been increased (in floor space) 413% since the war began. Production-capacity increases when the expansion of this plant is completed will range from 600% for extruded shapes to 1100% for tubing. All of this is part of the company's self-financed 200 million dollar expansion program.

Allegheny-Ludlum Steel Corp.'s melting capacity for special steels is being increased by 50,000 tons annually through the installation of 2 new 35-ton Swindell-Dressler electric furnaces at Brackenridge, Pa.

Jos. T. Ryerson & Son, Inc., are increasing their office space and plant service facilities at Chicago to expedite steel deliveries and service.

Pittsburgh Metallurgical Co., producers of ferro-alloys and metals, is building for September 1941 operation a new plant at Charleston, S. C., to supplement the production of their Niagara Falls plant.

A new magnesium alloy foundry known as *Light Metals, Inc.*, 1100-1198 E. 24th St., Indianapolis, Ind., has been established. It will serve primarily the territory of Indiana, Ohio and Missouri, with a monthly capacity of about 20,000 lbs. of finished magnesium alloy castings.

Ampco Metal, Inc., Milwaukee, Wis., is erecting a new foundry addition that will practically double its plant capacity. Also

in Milwaukee, *Harnischfeger Corp.* has recently started construction of an all-welded apprentice building for training purposes.

The Induction Heating Corp., manufacturers of induction heating equipment for surface hardening, brazing, melting, annealing, etc., has moved to larger quarters at 389 Lafayette St., New York. *The Lindberg Engineering Co.* has moved into a new quarter-of-a-million dollar plant at Campbell & Hubbard Sts., Chicago, that more than doubles the company's capacity for making furnaces and heat treating equipment. *Metal & Thermit Corp.*, New York, began on July 1st the construction of a new research laboratory at Woodbridge, N. J.

Solvay Process Co., manufacturers of alkalies and nitrogen products, some of which are employed in metal-refining, has recently established a separate Product Development Section with W. E. Blair as manager and D. H. Ross assistant manager. And *Vascoloy-Ramet Corp.* on July 10th opened a district sales engineering office at 50 Church St., New York, in charge of Eugene Roth.

Inkless Recorder

A new low-chart-speed recorder, which telescopes 30-day load and voltage surveys formerly requiring 60-foot strip charts into a chart only 30 in. long, has been announced by the Meter Division of the *General Electric Co.*, Schenectady, N. Y.

The new instrument, an addition to G. E.'s Type CF line of inkless recorders, has a chart speed of only 1 in. per day. Thus, the operating record for an entire month can be checked at a glance, and the spread of current or voltage, as well as the duration of maximum and minimum values, is immediately apparent.

In many central-stations and industrial applications the new low-chart-speed recorder will probably be used in conjunction with a higher chart-speed recorder. Unusual conditions indicated on the 30-in. chart can then be located quickly and studied more closely on the regular 60-ft. chart.

The 1-in. per-day speed of the new recorder is made possible by the inkless recording mechanism, which makes an impression by pressing the chart against a typewriter ribbon. The inkless feature obviates the freezing and evaporating difficulties in extreme temperatures that are said to be had with pen-and-ink mechanisms, and the recorder will function accurately in temperatures ranging from —10 deg. F. to —120 deg. F.

Setting up the new recorder for operation is described as simple. Date and time may be marked at the beginning of the record, and date and time of any other point can be found quickly by counting each 1-in. time line as a day.

The new CF-1 low-chart-speed recorder is obtainable as an ammeter or a voltmeter.

New Immersion Tin Finish

The Alrose Chemical Co., Providence, R. I., announces the development of "Bon White," a new immersion tin finish, applicable to all copper and brass surfaces.

The new coating may be applied in ten sec. and can, in many instances, replace slow boiling methods of tin plating. The solution is prepared by dissolving 16 oz. sodium cyanide and 6 oz. of Bon White paste in one gallon of boiling water. When cooled to room temperature, no further heat is necessary and no adjustment is required, as the material is completely plated from the solution.

The life of the solution depends on the production volume. Enamel and glass containers are used and the work can be handled in baskets or on wire.

The new process is said to give an inexpensive, highly-effective white finish and, being pure tin, to offer considerable tarnish resistance.

● Improvements in their various grades of Kennametal steel cutting tool carbides to provide both greater hardness and greater strength than previously present, have been announced by *McKenna Metals Co.*, 158 Lloyd Ave., Latrobe, Pa. The new hardness and strength values for the four standard grades of Kennametal range between 77.6 and 80.6 Rockwell C hardness, and 350,000 and 225,000 lbs./in.² transverse rupture strength, it is stated.

News of Metallurgical Engineers

Frank H. Adams, for 15 yrs. vice president and general manager of Surface Combustion Corp., Toledo, Ohio, has been elected president. . . . *C. R. Cox,* formerly vice president in charge of operations of National Tube Co., Pittsburgh, is now executive vice president.

E. N. Case and *James Ceriani* have joined the research staff of A. F. Holden Co., New Haven, Conn. . . . *C. B. Voldrich,* formerly associate materials engineer of the Newport News Office of Supervisor of Shipbuilding, Navy Dept., is now welding engineer at Battelle Memorial Institute, Columbus, Ohio.

Frank T. Sisco has given up the editorship of Alloys of Iron Research of the Engineering Foundation to become assistant secretary of the American Institute of Mining & Metallurgical Engineers and secretary of the "metal divisions." . . . *John S. Marsh,* formerly associate editor, succeeds him as editor.

Meetings and Expositions

American Institute of Electrical Engineers, Pacific Coast convention. Yellowstone National Park. Aug. 27-29, 1941.

American Chemical Society, semi-annual meeting. Atlantic City, N. J. Sept. 8-12, 1941.

Technical Association of the Pulp & Paper Industry. Ann Arbor, Mich. Sept. 17-19, 1941.

Association of Iron & Steel Engineers, annual convention. Cleveland, O., Sept. 23-26, 1941.

American Mining Congress, annual metal mining convention and exposition. San Francisco, Calif. Sept. 29-Oct. 2, 1941.

WANTED: A used metallographic microscope, preferably inverted with camera. Should be in good condition and suitable for magnifications up to 1200. R. Wallace & Sons Mfg. Co., Wallingford, Conn.

FREE SERVICE DEPARTMENT

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd. St., New York.*

POSITION WANTED: Experienced metallurgist, with steel mill, heat treating, and research technical experience combined with wide association with finished product fabrication, including methods, costs and quality. Permanent position. Cornell graduate. Box MA-23.

POSITION WANTED: Metallurgical engineer. Technical graduate. Employed. Year and a half experience in laboratory control and production engineering. Desires position with well-established firm offering a future. Willing to locate most anywhere but prefer the mid-west. Box MA-24.

Mending Metals

A new synthetic developed for the repair and cementing of metal surfaces of various types is announced by *Perfect Manufacturing Co.,* 3317 Madison Rd., Cincinnati.

Known as "So-Luminum," the new product is said to be the only plastic mender for metals that withstands the heat of boiling water and direct flame. It may be used on aluminum, stainless steel, iron, porcelain, enamelware, etc.

The compound is applied without heat or electricity. A drop of it squeezed on a hole, crack or joint dries hard overnight.

● A new substitute for aluminum paint (called "Light Gray Totrust", manufactured by *Wilbur & Williams Co.,* Park Square Bldg., Boston) is claimed to look like aluminum paint, to have about the same light reflection, to cost much less and to have superlative durability and protectiveness.

● A new alkaline copper plating process of *United Chromium, Inc.,* 51 E. 42nd St., New York, is claimed to save time and to give a smooth, fine-grained copper deposit even in heavy thicknesses.

METALLURGICAL ENGINEERING shop notes

Die Casting Design—Side Holes Without Extra Cores

by E. K. Vaughan
New Jersey Zinc Co.

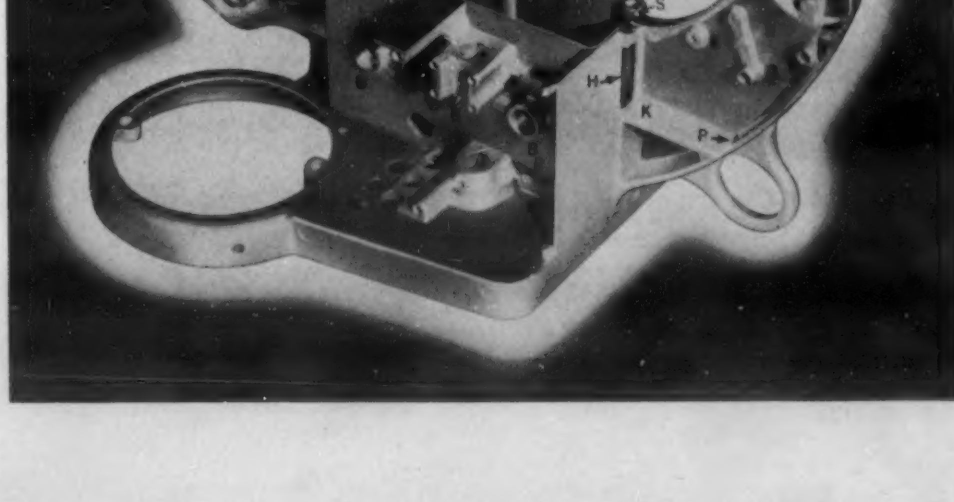
An expensive die is required, at best, to form a die casting as complex as that shown here (for a movie projector), yet, by forethought in design, the cost of the die can be kept at a minimum and the resulting casting will be far cheaper than if the part were formed by other means.

It may be helpful to visualize this casting in the die from which it is formed. The die is parted in the plane of the edge of the hollow projecting arms, at "P." All the recesses marked "R," all the bosses "B" and the projections "C" are formed by the rear half of the die.

The latter carries fixed pins, which core most of the holes that face to the right and that have their axes at right angles to the parting plane (parallel to die motion). Similar bosses and projections on the opposite face are formed by the front half of the die.

It is necessary, however, to have a separate slide to core the large recess below the face "F" and the large hole through this face. This core forms several bosses within the recess and carries several pins, which core a corresponding number of holes having axes parallel to the motion of the slide.

Another slide is required to form the box-like opening "O," the bosses in the corner and at the far side of the opening, and a partition extending upward from the bottom of the box to the level of the bottom of the oblong openings "H." The latter, though opening at 90° to the core that forms the box interior, are made by this core, *not by separate cores.*



This elimination of separate cores is accomplished by the simple expedient of providing, on the core, bosses that form the slots or recesses "S" and extend down to the level of the ribs "K." The thickness of the bosses on the core is equal to that of the end walls in which the openings are formed, and, when the die is closed, the faces of these core bosses come as close as practical to that portion of the rear half of the die that forms the outside face of the ends of the box. Naturally, a flash is formed at the openings "H," but this is easily removed.

Demonstrating "Time-Quenching"

by K. J. Trigger
University of Illinois

In demonstrating the principle of "time-quenching"—fast cooling only through the high temperature range, followed by slow cooling to develop full hardening without cracks—to defense-training groups and regular classes, the writer has had marked success with the following exercise.

Two samples of 5/32-in. diam. drill rod about 4 in. long are heated to 1450 deg. F. for 5-10 min. One sample (A) is then quenched in cold water and the hardness determined. Sample (B) is quenched in a lead bath at 700 deg. F. for 5 sec. and then air-cooled. Typical results are as follows:

Sample A—Average Rockwell C hardness, 8 readings—66.5
Sample B—Average Rockwell C hardness, 8 readings—67

Generally, cracks are visible in Sample A and absent in Sample B.

This simple exercise serves to impress the student and practical man alike that once the rapid transition range of austenite (the nose of the "S" curve) is passed, the steel may be readily and fully hardened without the high internal stresses that accompany a full quench.

Using the exercise as an illustration, it is much easier to convey the idea of time quenching as applied to carbon steel taps, reamers, etc.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Design and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms: Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

1a. Ferrous

Open Hearth Refractories

"Basic Open Hearth." J. H. Chesters. *Iron Age*, Vol. 147, May 22, 1941, pp. 39-46; May 29, 1941, pp. 41-47. Practical.

Construction data and refractory technique (for British furnaces) above the sill plate level are given. The furnace is a small (80 ton) type of furnace charged with pig iron and scrap and fired with producer gas.

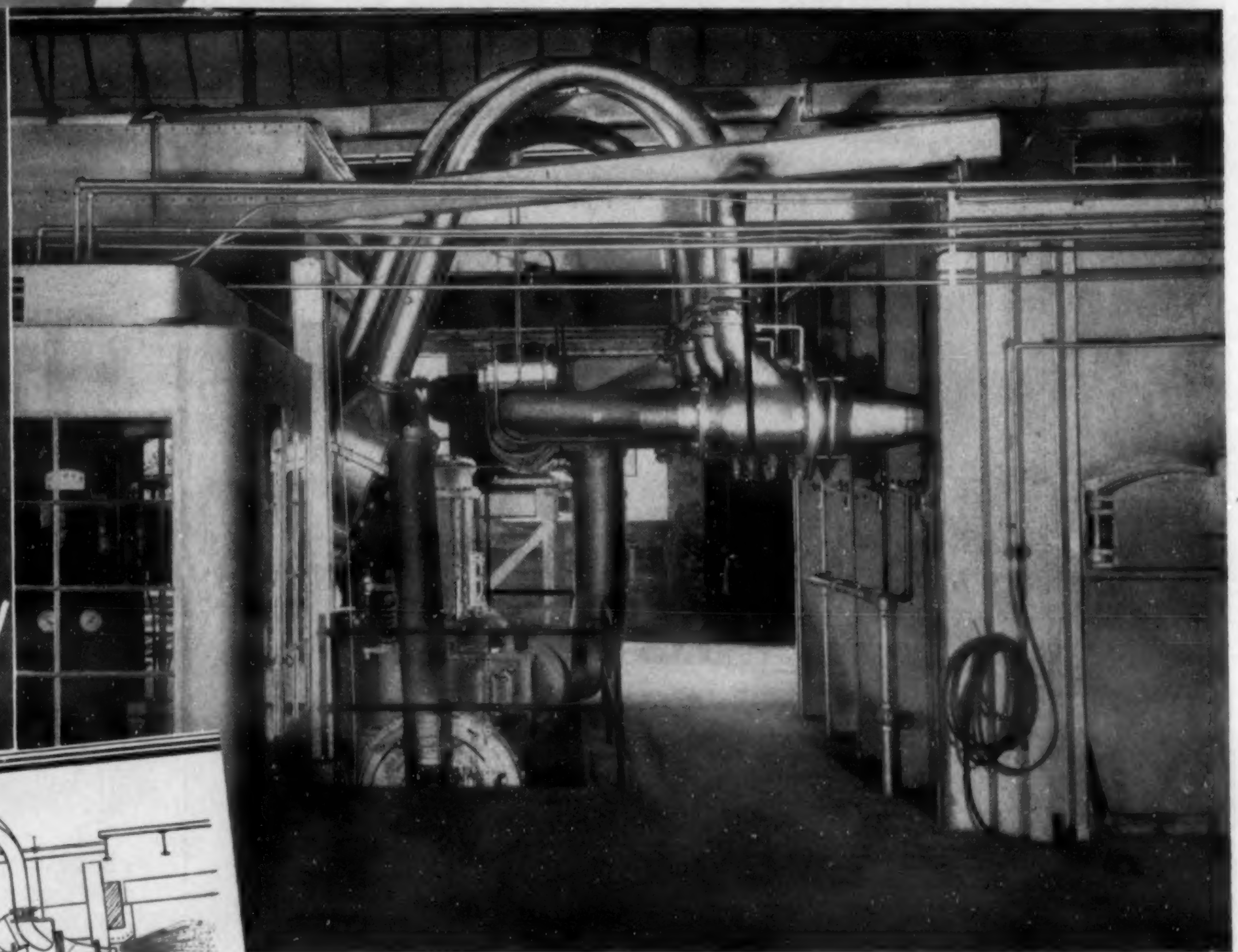
Only the hearth should come in contact with the molten metal, but the whole inside is bathed with an "atmosphere" rich in iron oxide and lime and hence must be constructed to resist basic dust at temperatures as high as 3092° F. Refractories used for tilting furnaces are the same as for fixed furnaces but the back wall cannot be built of silica brick since when the furnace tilts it becomes covered with a slag rich in CaO, FeO or MnO.

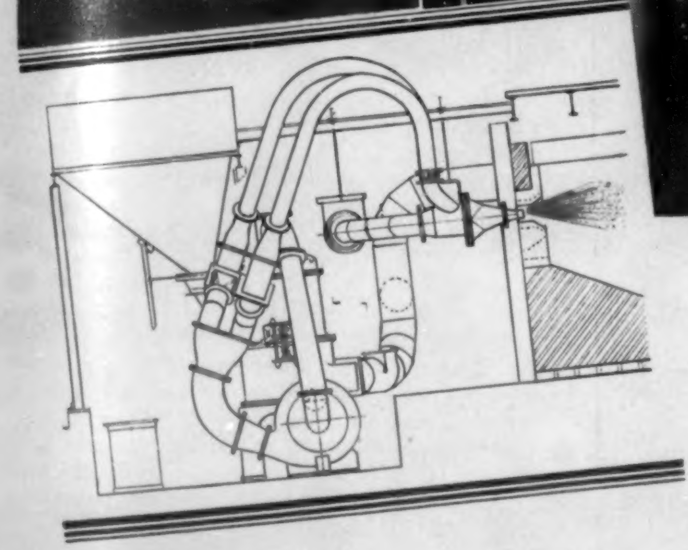
The simpler the design the less strain is imposed on the refractories. The main object of a ribbed roof is to provide additional strength without an increase in roof weight. In Great Britain, roofs tend to be thinner, the 12-in. roof with 14-in. ribs being more common. Bonded roof takes longer to install and more care in construction, but it is more satisfactory and more likely to keep its shape.

Suspension of roof by steel hangers has some advantages, notably the avoidance of stresses produced on the side of the brick during heating. A particular disadvantage lies in the need for protecting the hangers from oxidation.

The use of felt is advantageous. Cement, if used, should be of a refractoriness almost equal to that of brick. Where roofs are insulated Vermiculite should be used. It is difficult to make silica brick water-tight but the following composition is useful: sp. gr. not over 2.38 and average to be less than 2.36; chemical analysis, silica more than 94.5, alumina less than 2.00 and lime less than 2.50%, with a melting point minimum of 3110° F.

The rate of roof wear increases if the atmosphere is strongly reducing, as may occur when a high percentage of coke oven gas is used or when water vapor comes in contact with the roof. Where the roof or side wall has to be patched with silica brick while the furnace is in operation, spalling can be reduced by boiling the bricks in tar or dipping them in creosote prior to use.





Possible ways of increasing roof life are: (1) the use of silica brick of higher bulk density; (2) bricks made without added bond; (3) study of factors controlling glazing and obtaining a roof that matures readily; (4) the use of basic refractories over the taphole and possibly for the whole roof; and (5) extended use of roof pyrometry.

In England, back walls are constructed of chrome magnesite bricks. With sloping walls almost any refractory brick can be used since it is protected by dolomite or magnesite fettling material, but a basic brick is preferred since it reduces the reaction between brick and fettling.

With tilting furnaces back walls are generally made of magnesite or chrome magnesite bricks and parging cement. Experience has shown that chrome magnesite bricks are more economical since: (1) Silica bricks must have basic bricks as a base; (2) repairs are less frequent; (3) strain on roof, due to back wall repairs, is eliminated; (4) there is less cut in bands due to silica drip; and (5) higher working temperatures are possible.

Division of the front wall into separate pillars is a definite weakness. It can be minimized by building the wall thick at the bottom, and where possible on the "batter," and sloping outwards on the inside face. Door jambs should also slope outwards.

With most British furnaces the front wall is built of chrome-magnesite bricks, although silica brick is also used. Silica bricks are more suitable from the point of view of resistance to furnace atmosphere, but are likely to spall unless heated up slowly.

Recently built furnaces have ports of special design, such as Venturi, Maerz and Friedrich ports, which are water cooled. Ports are constructed, if not of chrome-magnesite or other basic brick, at least with basic face. When water cooling is used, port bricks last longer. Good results have been obtained in Venturi ports with brick of high thermal shock resistance made from dead-burned Grecian magnesite. VSP (1a)

Blast Furnace Filling

"MECHANICS OF BLAST FURNACE FILLING." T. H. KENNEDY (National Tube Co.) *Blast Furnace & Steel Plant,* Vol. 29, May 1941, pp. 501-508. Investigation.

The effect of bell overhang, hopper design, speed of dumping, size of charge, etc. on distribution of stock in the blast furnace was examined. A representative section of the top was selected and used as the dimensions to which a chute was constructed, the width being 4 ft.

The chute angle and distance between chute lip and wall correspond exactly to furnace dimensions. The apparatus was set 8 ft. above the floor to allow the stock to fall the same distance it does in common operating practice. The throat-to-bell ratio of the furnace was 1.98:1.00. The gate or hopper had a 9½ degree angle to conform with the design of a conventional hopper. The gate could be lifted at any desired rate.

A smaller hopper was built above the large hopper in such a position that the crest of the ridge across the large hopper was directly above the contact point between the chute and gate. Each step in the tests was recorded photographically.

A system of slots on the sides of the chute permitted control of the amount of overhang, which is the vertical distance between the horizontal planes formed by the large bell bottom when closed and the inner large bell seat. The amounts of overhang used were 1.19 in., 5.96 in. and 10.71 in., which are equivalent to a difference in diameter of large bell and hopper of 2, 10 and 18 in., respectively. 1800 lbs. of ore was dumped each time and the dumping rate was 2 ft. in 10 sec.

The results indicated that an increase in the amount of the large bell overhang by reducing the hopper diameter is equal in effect to increasing the diameter of the large bell, which is to deposit material nearer the furnace walls. The last of the ore to leave the chute when the ore is dumped above fills the depression behind the ridge, so that the finished pile of ore is much the same in all cases.

The addition of 800 lbs. of coke charged on top of the 1800 lbs. of ore in the large bell accentuated the effect of increased bell overhang. However, with the ore-coke filling, sufficient coke is mixed with the last of the ore charge to fill the valley behind the crest of the ridge and prevent the last part of the ore from filling that space as it did in the first tests.

Screen analyses of the ore dumped with the different amounts of overhang showed no definite relationship within 2 ft. of the wall between the average size and the point of dumping. There is some segregation of lumps 3-4 ft. from the wall, which varies inversely with the amount of overhang.

Tests with loads of 2300 lbs., 4000 lbs., and 5500 lbs. of ore showed that proportionately more ore will fall near the wall when charged in larger quantities. The relationship between screen analyses and in-


THE NEED FOR
INCREASING
PRODUCTION

creased ore load was similar to that in the preceding tests. The theoretical effect of increasing the size of the large bell without a change in hopper dimensions will be to increase the radius of the annular ridge formed by the falling stock by about 2½ times the increase in large bell radius.

It is possible that an increase in bell overhang, either by reducing the hopper diameter or by slightly increasing the bell diameter without changing the hopper, may be substituted for a larger increase in bell diameter. Tests with 1800 lbs. of ore and 800 lbs. of coke dumped at speeds of 5, 10 and 15 sec. when the bell overhang was 5.96 in. showed that an increase in dumping speed will cause the material to be cast nearer the wall, and indiscriminate bell dumping speed will be reflected in a variable distribution.

Other observations show that within certain limits, the ore is distributed over a greater area as the stock-line is raised. The area of large bell, area of stock-line, bell overhang, bell opening speed, height of stock, design of small bell and hopper, and character of materials used are complementary in their effect upon distribution and furnace operation. MS (1a)

Cupola Control

A Composite

Two recent articles, one of British origin and the other German, present between them a good set of practical rules for cupola operating control.

According to C. A. PAYNE ("The Outline of Cupola Control," *Foundry Trade J.*, Vol. 64, May 15, 1941, p. 331), the height of the charging still should be such as to give adequate cooling of gases by the stock without the weight of stock being sufficient to crush the bed-coke. The well-capacity determines the height of slag-hole and tuyeres.

Excessive lining irregularities indicate the need for stripping and relining the zones involved. "Armor plating" below the charging-sill is to be recommended.

Tuyeres, on the first signs of warping or burning-on, should be replaced. Tapping and slag-spouts should be kept rigid, and should be replaced when burnt. Patching requires as long an air-drying as possible, final drying being by means of a fire kept below tuyere level.

The bed-coke is put on a portion at a time, each portion burning through thoroughly before further additions. The bed-height, checked after poking and leveling, is fixed by the melting zone, and is a function of blast-pressure. Above this are required the layer of "safety-coke" and the layer of charge-coke for the first charge.

The order of charging, more important with steel-bearing charges, is determined by the carbon pick-up characteristics of the cupola. Low pick-up cupolas require steel charging on to coke, followed by, say, return-scrap and pig iron; the reverse order is used with high pick-up cupolas, depending, of course, on the carbon content required.

Each coke-charge should be a complete layer between metal-charges. The charge-coke weight, fixed by cupola dimensions as a 7-8 in. layer for optimum conditions, determines the weight of metal-charge according to the metal/coke ratio required.

For given combustion conditions, the air—of predetermined oxygen content i.e. corrected for humidity—required to burn 1 lb. of carbon is fixed, hence the volume of air in unit time under given atmospheric conditions is fixed.

Speaking of blast volume, A. KNICKENBERG ("Praktische Winke aus dem Kupolofenbetrieb," *Giesserei*, Vol. 28, Mar. 21, 1941, pp. 121-129) states that it should be 5000-7000 ft.^{3}/min. for each sq. yd. of section, depending also on the type of burden. Blast pressure should not be less than 600 mm. measured in the forehearth.

The area sections of the tuyeres should be about 1/10 that of cross section area of the furnace; they can be too large but seldom too small, and one row of tuyeres is best. The thickness of the coke charge layer should be about 6 in. The coke charge must be increased 1% for every 30% steel addition, which corresponds to the amount required for the carburization.

X(1a)

1b. Non-Ferrous

Casting Light Alloy Pistons

"UNSOUNDNESS IN GRAVITY DIE-CAST SILICON-ALUMINIUM ALLOY PISTONS." R. T. PARKER. *Foundry Trade J.*, Vol. 64, Apr. 17, 1941, pp. 257-258; Apr. 24, 1941, pp. 277-279. Practical.

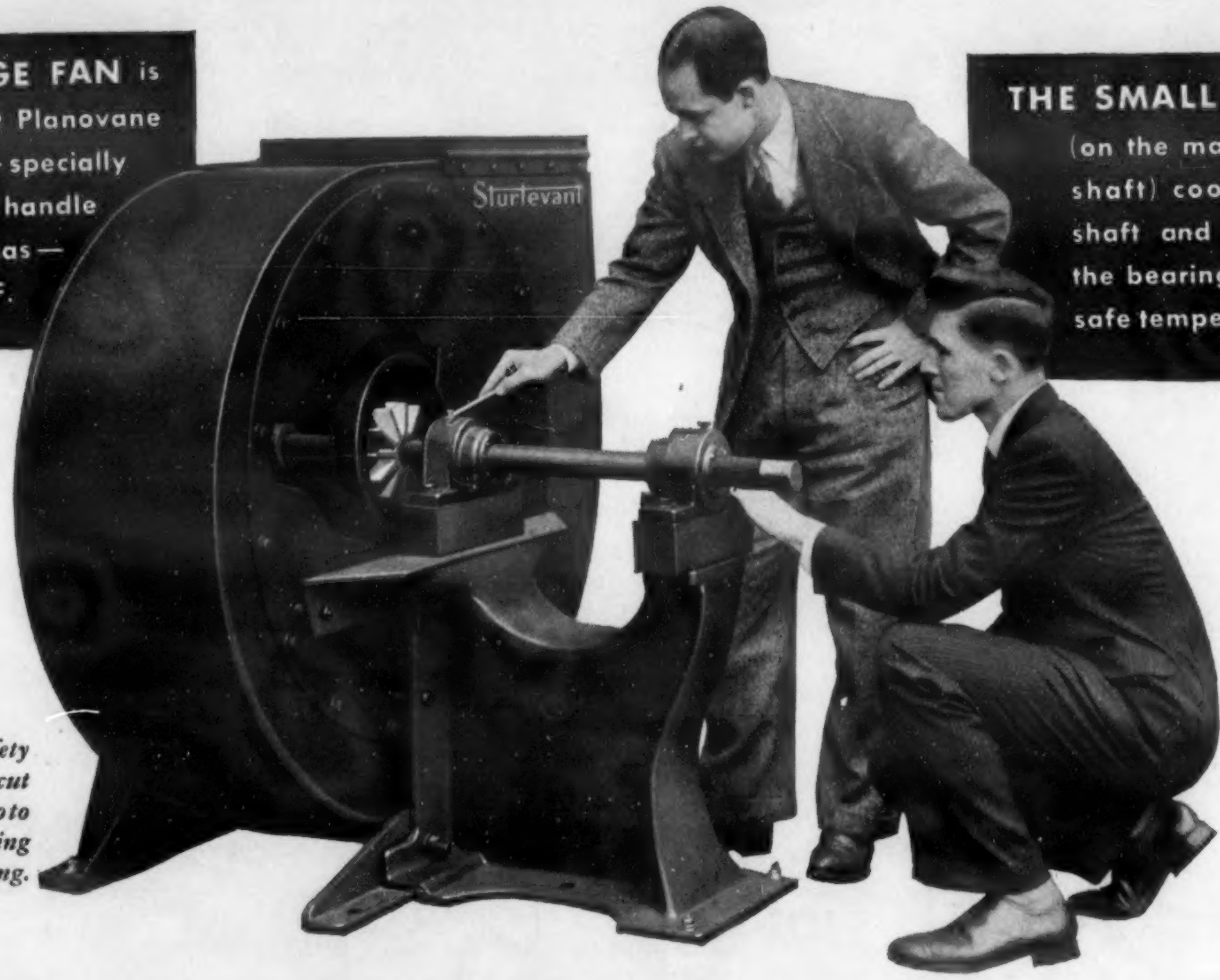
The permanent-mold process of manufacture of the pistons, examination of typical pistons, effect of atmospheric conditions, variation in quality of machined pistons, and effect of mold-assembly temperatures upon the soundness of pistons, are among the topics discussed.

The original problem was the occasional appearance during machining of fine unsoundness in pistons. The unsoundness appeared to be common to the production of the entire foundry at certain times, and no connection could be drawn between usually-suspected factors and unsoundness.

2 FANS are better than 1

. . . when handling HOT air or gases!

THE LARGE FAN is a Sturtevant Planovane Exhauster — specially designed to handle dirty air or gas — up to 900°F.

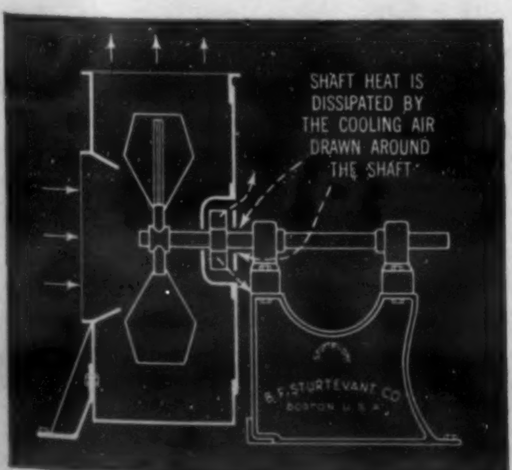


THE SMALL FAN (on the main fan shaft) cools the shaft and keeps the bearings at a safe temperature.

Side plate and safety guard have been cut away in this photo to show shaft cooling wheel and housing.

EXTRA Fan cools bearings—at no extra cost!

FREE AIR takes the place of water to keep shaft and bearings cool on this Sturtevant Planovane Exhauster. A special "heat-slinger" fan on the main fan shaft draws in cooling air as shown below, absorbs the excessive heat from the shaft—and discharges it back into the air.



Adds nothing to the cost of operation—yet eliminates cost and maintenance of water-cooled bearings.

Sturtevant Planovane Exhauster design is especially efficient where circulating systems require low volumes at high pressures. Large passages through the wheel and housing facilitate the handling of dirty, dust-laden air. Slower speeds and rugged construction make this unit extremely economical to operate and maintain.

Available with non-sparking wheels for handling explosive gases up to 700°F.—and with special wheels and casings where corrosive material is encountered.

When you buy fan-equipped ovens, dryers and furnaces, it will pay you to investigate Sturtevant High Temperature Air Handling Equipment. It is backed by 81 years of air engineering experience.

We will gladly furnish engineering cooperation or performance data on Sturtevant Fans and Exhausters for specific applications. Write direct to Hyde Park or the nearest Sturtevant office.

B. F. STURTEVANT COMPANY
Hyde Park Boston, Mass.
Branches in 40 Other Cities

Sturtevant
REG. U. S. PAT. OFF.
Puts Air to Work

The unsoundness was thought to result from gas contamination to a variable degree. This in turn must be caused by fluctuation in the usual sources of gas contamination, such as changes in atmospheric conditions and in melting practice.

Two experiments were made, one with metal of high gas content, and the other with metal of low gas content. The composition of the 2 batches of metal were as follows: High-gas metal: 0.91% Cu; 0.53 Fe; 0.02 Mn; 1.02 Mg; 11.72 Si; 0.10 Ti; 2.53 Ni; 0.012 Na; and low-gas metal: 0.94% Cu; 0.41 Fe; 0.02 Mn; 1.15 Mg; 11.86 Si; 0.03 Ti; 2.39 Ni; 0.0018 Na.

The effect of variation in gas content seems to be to alter very markedly the form of the gas-shrinkage unsoundness, which is always present to some degree. When the gas content is low, the unsoundness may be easily recognized as being largely due to shrinkage; furthermore such coarse unsoundness tends to be more or less central and less likely to be disclosed by superficial machining.

When the gas content was higher, a general type of unsoundness was found, and this persisted although the temperature of the mold-assembly was raised appreciably. Increasing the mold-assembly temperature with low-gas metal resulted in a rapid diminution of shrinkage. It has been shown also that variations in machining technique complicated the problem, since when the unsoundness was fine, the small cavities might be covered by flowing of the surface.

The investigation has shown that the examination of microsections is by no means sufficient when attacking problems of unsoundness such as the one outlined. The use of X-ray examination is a more practical method of attack.

The high-gas metal was prepared by ordinary methods, that is, it was produced by melting pig in an oil-fired furnace, and transferring metal from this furnace, to an oil-fired holding pot, open to the atmosphere. The low-gas metal was prepared by remelting pig in an electric furnace.

When the metal had reached about 1300° F. it was allowed to remain for 1 hr. with a gentle stream of nitrogen from a cylinder playing on the surface of the bath, the furnace being closed as far as the gas inlet pipe would allow. Casting in this case was done straight from the furnace. AIK (1b)

Aluminum Bronze Castings

"Solidification of Aluminium Bronze." C. H. Meigh. *Foundry Trade J.*, Vol. 64, Apr. 24, 1941, pp. 281-284. Discussion.

The influence of aluminum on the microstructure and tensile properties of copper alloys containing manganese is given in the form of a scale. At one end of this scale is the alpha range, containing less than 7.5% Al and at the other the beta range, containing over 11% Al. Between these extremities there is the duplex range of aluminum bronze alloys.

Another chart shows the influence of solidification speed on the microstructure and tensile properties of a typical alloy (in the duplex range) containing 9.7% Al; 3.0 Mn; 3.0 Fe; and 3.0 Ni, cast in a sand mold, in thickness varying from 6 in. to 3/16 in. It is shown that as the grain size decreases the mechanical properties increase in value.

Copper-aluminum alloys pass almost instantaneously from the liquid to the solid state, and in doing so the metal is reduced to 9/10 of its liquid volume before the commencement of ordinary linear contraction. Adequate feeding is therefore imperative.

In profiled castings various influences have their effect on shrinkage: (1) Slow pouring allows the metal to solidify and to start shrinking while the mold is actually being filled, thus reducing the amount of shrinkage in the finished casting. (2) The extreme plasticity of these alloys just below their melting point allows them to "give" when resistance is encountered from a core, or projection on the mold; this in turn results in reduced shrinkage in the casting.

Also (3) the relatively high tensile strength of the metal at temperatures of from below 1300° F. downwards enables it to crush the sand in the hardest mold. This tends to increase shrinkage of the finished casting. In general shrinkage increases with an increase of thickness of casting. AIK (1b)

Atmospheres in Non-Ferrous Melting

"Effect of Furnace Atmospheres in Non-Ferrous Melting." J. M. Kelly (Westinghouse Elec. & Mfg. Co.) *Am. Foundrymen's Assoc.*, Preprint No. 41-20, May 1941, 7 pp. Review plus research.

The importance of atmosphere control within melting furnaces used in the preparation of non-ferrous alloys is increasingly apparent. Defective castings, due to gas absorption as well as excessive

oxidation of molten alloys because of faulty furnace atmospheres have led to means of control over this source of possible trouble. Particularly is this control important in the preparation of high-conductivity copper castings and high strength brass and bronze.

The solubility of gases in liquid metals is a function of both temperature and pressure, as shown by familiar data on carbon monoxide, carbon dioxide and hydrogen in copper. Nitrogen is insoluble in solid copper and only slightly soluble in liquid, but oxygen dissolves in liquid copper very readily, and is generally present as cuprous oxide.

Oxygen and hydrogen in copper castings are objectionable because their presence in the liquid metal bath causes porous castings. Additions of 0.20% calcium boride in the ladle have been found to eliminate oxygen effectively without detriment to the conductivity of the cast copper.

The elimination of hydrogen from molten copper is not so simple. Considerable success has been had with additions of 0.20-0.40% cuprous oxide to remove the hydrogen, followed by deoxidation with calcium boride.

More positive control methods are offered by control of the atmosphere within the melting furnace. With an oxidizing gas, the molten copper will dissolve a given quantity of oxygen, which can be readily eliminated by deoxidation. Under these conditions the hydrogen absorbed will be very low.

Hydrogen may originate from grease and oil on scrap metal, from the fuel gas if combustion is incomplete, and from the humidity of the air used for combustion. However, the tests showed that sufficiently oxidizing atmosphere (10/1 air/gas ratio) would offset the effect of as much as 3.2% hydrogen in the furnace atmosphere, and would give such protection that copper castings melted down in it were satisfactory.

Other tests demonstrate that embrittling effects in copper castings and forgings are directly related to melting furnace atmospheres. For example, air-annealed specimens prepared in an atmosphere containing 6.1% hydrogen fractured in the bend test (90° bend) whereas a similar specimen made in a hydrogen-free atmosphere showed excellent ductility.

FPP (1b)

3-Layer Aluminum Electrolysis

NEW APPLICATION POSSIBILITIES FOR THE THREE-LAYER FUSION ELECTROLYSIS ("Nevere Einsatzmöglichkeiten der Dreischichten-Schmelzfluss-Elektrolyse") H. GINSBERG. *Aluminium*, Vol. 23, Mar. 1941, pp. 131-135. Descriptive survey.

The production of aluminum in the 3-layer bath (lowest layer aluminum mineral; middle layer electrolyte of cryolite or other fluoride; top layer molten pure aluminum) is surveyed as to the practical advantages so far obtained and the improvements that still have to be made.

At present, only about 1/3 of the electrical energy supplied is utilized for the actual production of aluminum. The remainder is transformed into heat, which though used for keeping the bath in a molten state is to a great extent lost by conduction and radiation; the temperature of the bath is about 550° F. higher than required for melting the aluminum because of the high melting points of the electrolytes used.

New developments reported in the patent literature that might improve this situation are surveyed. Better construction of the bath container is one source of improvement, but the main effort has been directed to finding electrolytes of lower melting temperatures. Thus, a French patent uses an electrolyte of cryolite, an excess of AlF_3, and $BaCl_2$, which melts at 1380° F. and is operated at 1475° F. A Swiss patent advocates only fluorides of aluminum, sodium, calcium and barium, which bath is operated at 1380° F.

The 3-layer electrolysis is chiefly used for the production of "purest" aluminum. The scrap metal for the anode (bottom layer) should not contain too much iron impurities. By adding copper (or, if the scrap contains sufficient copper) it is possible to reduce the iron content of the bath by segregation to 0.3% Fe.

Magnesium should not be added to the bath as it is a less noble element than aluminum and goes into solution. If too much magnesium is present it should be removed in a separate process in another furnace with a salt mixture of cryolite, sodium chloride and potassium chloride. In the bath, all but 0.02% Mg is then separated according to the reaction $3\,Mg + 2\,AlF_3 = 3MgF_2 + 2\,Al$.

The present current efficiency in the 3-layer electrolysis is about 85-90% with an energy consumption of 20-22 kw.-hr. per kg. aluminum metal. The consumption of graphite electrodes is 4-5 kg. per 100 kg. metal.

H. (1b)

Processing 2 and Fabrication

FORGING, FORMING, MACHINING
HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting, Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Soft Metal Tools for Pressing Aircraft Parts

"Soft Metal Tools." Alastair McLeod. *Sheet Metal Inds.*, Vol. 15, June 1941, pp. 774-778, 783-785. Survey.

The simple rope-operated drop hammer is still in wide use as a result of its flexibility and adaptability. Modern drop hammers are also giving good service in many shops. However, much evidence is being accumulated in favor of hydraulic presses, which generally use rubber-top tools.

Some years ago, the Germans mentioned the use of magnesium alloy or zinc alloy dies for short runs where steel or cast iron tools were not justified. Now, the punch (movable die) is usually zinc, lead or rubber, and may be either male or female; in most cases, the lower die is zinc and the other lead or rubber. In the case of the zinc die, a sand mold may be made in the conventional way from a wood pattern, or—quicker and equally effective—a plaster-of-Paris pattern may be constructed from a hand-fabricated part.

In melting the zinc, the first part of the charge is broken up fine and allowed to melt before the rest of the charge is added; in this way the bottom of the pot is protected from overheating. The rest of the charge is added and the temperature raised to 930° F. If desirable, alloying additions are now made. Pouring temperature is on the average 850° F.

The punch is cast into the female tool; if the former is zinc, the casting temperature is lowered by about 10° F. It will be noted that only one pattern is required for both tools. The setting shrinkage of the male member is sufficient to allow for the finished metal part to lie between the faces (this tolerance can be adjusted by preheating the female tool prior to casting its counterpart.) It is not good practice to use all new or all secondary metal in the melt.

The tools are finished either by machining or polishing. Stainless steel inserts in the lead die at the points of greatest wear have been advocated, but may lead to difficulty due to differential wear.

Great care is taken to preserve the face of the female tool in good condition, but the top tool can be used even though cracked. If a repair is necessary, this can be carried out with soft solder; however, the solder should be removed before remelting.

At one plant, good results were obtained with a combination of a rolled zinc die for the lower tool, and a rubber pad for the upper. No lubricant was used, and in effect the components were pressed *up* into the rubber die. Such cutting blocks or dies are simply laid on the upper face of the table with no attempt made to fasten them; the rubber pad acts as its own stripper.

There are 2 methods of using rubber in the form of an upper tool. With a press, the rubber pad is actually the tool and may be either pressed down on the components or receive the upward pressure of the lower tool and blank. For single operation work on a drop hammer, rubber slabs may be used to mitigate the severity of the draw, dividing the operation into a series of stages. JZB (2)

Effect of "Atmosphere" in Plating

Investigations on Electrolytically-Deposited Metals — Influence of Atmosphere above the Electrolyte (Untersuchungen über elektrolytisch abgeschiedene Metalle—Der Einfluss der Atmosphäre über dem Elektrolyten auf das Abscheidungspotential) B. Kassube & H. Schmellenmeier. *Z. Elektrochem.*, Vol. 47, Apr. 1941, pp. 309-313. Original research.

When producing heavy iron plates electrolytically in chloride baths, bag-shaped growths were observed, especially near the edges. In spots where a hydrogen bubble was formed, the deposit grew very rapidly along the gas-electrolyte interfaces. The growth started all around the blisters and finally closed up around them.

Another observation was made with a bright tin bath, in which the bulk of the plate still took a dull finish, while a zone of approx. 0.4 in. at the upper edge came our bright. Deposit potentials were measured at various locations on the cathode with zinc, tin and iron.

According to the measurements the observations made are explained as follows: The current density is greatest near the edge of the plate; this favors hydrogen formation, which, in turn, decreases the potential so that increased metal deposition occurs, which again increases the current density. The process amplifies itself until the hydrogen bubble is all enclosed.

The glossy zone at the gas-electrolyte interface is also explained by the fact that the current density is increased at the upper edge of the plate. The atmospheric oxygen hampers reduction at the upper edge and thus furthers glossiness of the deposits. If a hydrogen atmosphere is maintained above the bath no increase in potential is found.

RPS (2)

Production Machinability

"What Machinability Means to Defense." A. H. d'Archambal (Pratt & Whitney) *Amer. Machinist*, Vol. 85, Apr. 2, 1941, pp. 286-8. Practical.

S.A.E. X1112, which is the freest-machining steel available, is used where strength is not a major requirement. Steels of the S.A.E. X1300 type have better strength but poorer machinability.

The machinability of the non-free-machining low-alloy steels is far more dependent on grain size, hardness and microstructure than on composition; if the first 3 factors are correct, there is very little difference in machinability up to 300 Brinell. The optimum condition depends upon the composition of the steel and the machining operation.

Generally, a spheroidized structure of fairly low hardness is best for roughing operations on screw machines. In some cases, as in die-threading S.A.E. 4140 on an automatic screw machine, a special normalizing treatment giving a banded structure is best.

There is an increasing use of molybdenum steels such as S.A.E. 4340 where machining must be done at higher hardnesses. Steels with coarse actual grain size have better machining properties than finer-grained steels, resulting in smoother finishes, longer tool life, and high production speeds.

The addition of sulphur or selenium to stainless steel improves machinability with little effect on corrosion resistance. Air hardening 1% C, 5% Cr die steel is less difficult to machine than the high-carbon, high-chromium die steels.

Some reports have indicated that leaded steels possess improved machinability with the same mechanical properties as similar steels without lead. The uniformly distributed lead particles give broken chips during machining and reduce frictional heat.

Sulphur-bearing oil is used on many operations where soluble oil was formerly used, with resultant longer tool life and smoother machined surfaces. Kerosene with some paraffine oil or lard oil is successful as a cutting fluid for all types of aluminum and magnesium.

Carbon tetrachloride additions, particularly to sulphur-base oils, result in a remarkable improvement in machining operations, but the toxic properties of carbon tetrachloride fumes have prevented its widespread use. Carbon tetrachloride appears to reduce adhesion between chip and tool, thereby preventing a built up edge.

JZB (2)

Mechanized Furnaces

"MECHANIZED HEAT TREATMENT." A. G. ROBIETTE & F. KERFOOT. *Metal Treatment*, Vol. 7, Spring 1941, pp. 3-9. Practical survey.

For batch furnaces, the forked-arm charging machine used in conjunction with a grooved hearth is the most popular type of equipment. By this means, the charge may be readily transferred to cooling racks or to a second furnace for further treatment.

For continuous furnaces, gravity feed by an inclined hearth is simple but suited only for regular shapes. Conveyors may take the form of the work itself (if wire or strip), overhead conveyors (often on the counter-flow system to secure thermal recuperation), sprocket-driven heat-resistant link chains, wire mesh belts (for small assemblies) or articulated links. Pusher furnaces are used for large loads, where the weight of belts and their large heat capacity make the use of belts impractical and costly.

An interesting type of special furnace employs a double-drum system to introduce and remove small pressings and blanks from the heating zone and thereby achieves high thermal efficiency. Driven roller hearths are used for sections, rod, tube, and strip and obviate the need for heating "dead" material in the conveyor.

"Walking beam" furnaces are used for annealing deep drawing steel and tinplate. In one form of rotary furnace ("pan dumper") the hearth consists of a number of pans pivoted on a revolving spider. The pans are tilted above a discharge shoot leading to the quench after they have passed through the heating zone. JCC (2)

Plating Metals on Non-Metals

"HOW TO PLATE METALS ON NON-METALS." ADOLPH BREGMAN. *Iron Age*, Vol. 147, June 12, 1941, pp. 50-54; June 19, 1941, pp. 46-49. Practical review.

Today the largest single use of "electroplasty" is electrotyping, and the list of products so electroplated is almost endless. The methods in use include (1) binder and conducting coat combination; (2) sprayed metal; (3) cathode sputtering; (4) evaporated metal or vacuum deposition; and (5) silvering by chemical reduction or precipitation.

The binder and conducting coat combination is the most generally used for it is flexible and applicable to a wide variety of products. In some forms it has certain disadvantages; its deposit is not uniform and has a tendency toward "orange-peeling." A silver conducting coat eliminates some of these disadvantages but it is fragile.

Metal spraying is a simple process, calling for cleaning of work, roughening the surface and application of molten metal, fed in wire form to a heated air gun. This method is generally applicable to structural installations, but it can also be used for small work where the granular effect of the metal surface is not objectionable.

Cathode sputtering is expensive but a very fine process. The porosity of the deposit decreases with the thickness of coating. This process is used for preparing fine mirrors, metallizing fabrics, etc.

The process of coating a non-metal with a metal by electrolysis calls for the application of a bonding coat, the application of an electrically conductive film, and electrodeposition to the desired thickness, after which any other finish may be applied. Porous articles are treated to make the surface proof against liquid penetration. In all cases where adherence is important, either shellac or lacquer is used. If bronze powder is applied by brush, it should be preceded by a coat of boiling linseed oil.

The conducting films applied may be of graphite, bronze powder, silver or silver nitrate. Graphite is used for coating wax. The most commonly used material for sensitizing the general run of metallized articles is composed of: 1 fluid oz. nitrocellulose lacquer; 3-7 fluid oz. lacquer thinner; and 2 fluid oz. copper bronze or lining powder.

Sometimes it is best to apply a silver deposit to bronzed work before copper plating. The silver may be applied by pouring the solution over the work. Silver sulphide is often used as a conductive coating over shellac.

Finely detailed decorations are difficult to coat with bronze powder or graphite. In such cases sensitizing with a film of silver similar to that used for mirrors may be used. Bakelite may be sensitized by dipping in a silvering solution; the formaldehyde in the bakelite takes the place of a reducer.

In the treatment of plastics in general, the operation is begun with 2 bonding coats, drying after each coat. Parts may be painted or sprayed with bronze powder mixture. Smooth plastic surfaces may be roughened before silver-coating.

One recent process includes the following operations: (1) The plastic is cleaned in mild alkali; (2) rinsed and dipped in dilute acid, and rinsed; (3) soaked in tin chloride solution and rinsed; (4) a con-

ducting and bonding metal coat is applied consisting mostly of silver; and (5) the work is rinsed and plated in acid copper solution. VSP (2)

2a. Ferrous

Induction Hardening

"Surface Hardening by Induction." H. B. Osborn, Jr. (Tocco Div., Ohio Crankshaft Co.) *Trans. Electrochem. Soc.*, Vol. 79, 1941, Preprint No. 24, 26 pp. Descriptive review.

High-frequency induction hardening results in the production of locally hardened surfaces having the desired depth of hardening, and causes practically no distortion or scale formation. It eliminates localizing pretreatments, such as copper plating or copper painting used in conjunction with carburizing.

The automatic regulation of power and the short time cycles of heating and quenching make the method amenable to production schedules. The heating is accomplished by high frequency currents of 2,000 to 100,000 cycles—the higher frequencies being used for more superficial hardening.

The metallurgy of induction hardening differs in some respects from that of the conventional furnace treatment, as the rate of carbide solution is greater, the hardness higher, and the martensite is nodular instead of acicular as with furnace hardening.

Carbide solution occurs very rapidly in induction heating. As the total heating time may be only 2-3 sec., the temperature is in excess of the critical temperature for less than a second. Experiments indicated that complete carbide solution and homogenity may be accomplished in 0.3 sec.

Higher maximum hardness results when the same steel is heated inductively than when heated thermally. On the Rockwell "C" scale, this increase is about 2 to 3 points for 0.7% carbon steel and 5 to 6 points for 0.1% carbon steel. This higher hardness is ascribed to a finer nodular and more homogeneous martensite, which results from a more thorough carbide diffusion than is obtained with furnace heating.

The equipment used for induction hardening consists of an inductor, fixtures for quenching, transformers, capacitors, automatic timing controls, and a high-frequency generator. The latter may have capacities up to 1,000 kw. at 2,000 to 10,000 cycles and generate voltages from 200 to 1,000 v. However, small compact units, generating 10 to 100 kw. at 10,000 cycles are now available. The inductor is one or more turns of copper made to fit the work.

Steels to be processed must have a carbon content sufficient to produce the desired hardness. Any material that can be hardened by heating and cooling can be hardened by the induction method.

Many applications of induction hardening are found in the automotive and related industries; for example, crankshafts, camshafts, track pins, piston pins, etc. Some unique applications are a simultaneous hardening of steel and brazing to copper; and the tip annealing of brass cartridge shells. [*A new field for induction hardening—the hardening of the inside surfaces of cylinders, tubes, etc.—was the subject of an article in the June issue of* Metals and Alloys, *pp. 713-722.*—F.P.P.] AB (2a)

Weld-Cracks in Parent Metal

"Weldability—Base Metal Cracks A Review of the Literature to July 1, 1939." W. Spraragen & G. E. Claussen. *Welding J., N. Y.*, Vol. 20, May 1941, pp. 201s-219s. Correlated abstract of 147 references.

Cracks in welded parts traceable to the welding are divided into 2 classes: cracks that appeared before the welded part was handled or placed in service, and cracks that appeared upon application of external load or after the welded part was placed in service. The cracks that are the subject of the present review are those that started in the base metal and before the welded part was placed in service.

The major class of cracks, called "hard cracks," start in the hardened zone close to the weld during cooling and seldom have any relationship with defects, such as laminations or porosity, in either the base or weld metal. Prevention of hard cracking is possible by reducing the carbon content of a sensitive steel that is capable of quench hardening, by preheating to 400°-575°F. (used for rail steels) many of the sensitive steels, by the use of electrodes depositing weld metal containing less than 0.10% C, less than 0.30% Mn and less than 0.05% Si for welding high tensile steels, or by the use of austenitic electrodes, which produce weld metal of high ductility.

The lowest hardness to be associated with hard cracking is 350 Brinell developed in a 0.20% C, 3.5% Ni steel. The cause of hard cracks is considered to be the tensile deformation beyond the capacity of a zone that is (or later becomes) martensitic as it cools from the welding temper-

How Columbium Helps Speed Fabrication of Stainless Steels

THE addition of columbium to chromium-nickel stainless steels for minimizing susceptibility to corrosion at the grain boundaries is now more important than ever. Columbium counteracts the effect on resistance to intergranular corrosion of the higher carbon contents necessitated by the use of increasing amounts of scrap in the charge. When these steels contain the correct amount of columbium, they can be welded with columbium-bearing welding rod, and stress-relieved if necessary, without requiring any subsequent heat-treatment to restore full corrosion resistance. This eliminates a costly and time-consuming fabricating step.

For welding austenitic stainless steels containing columbium or titanium, it is desirable to use columbium-bearing stainless steel welding rod to prevent grain-boundary corrosion in the weld, since columbium does not readily burn out . . . When chromium, nickel, and columbium are properly balanced in stainless steel castings, the castings have good physical properties in the as-cast state, besides being immune to intergranular corrosion. Here again, heat-treatment to restore chemical resistance or physical properties is eliminated.

Our metallurgists can tell you more about columbium and its effect on steel, and can give you practical, on-the-job help in the manufacture, fabrication, and use of stainless steels, and other steels as well. This service is supported by more than 35 years' experience in the production and use of quality ferro-alloys.

Why not ask for this help whenever you need it, without obligation.

ELECTRO METALLURGICAL COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York, N. Y.

Items of Interest about other "Electromet" Ferro-Alloys

•

Silico-Manganese Improves Low-Carbon Steel — Excess dissolved oxides in the lower-carbon grades of rimming steel for deep drawing purposes may be eliminated through the careful use of small amounts of silico-manganese. This simple operation of washing the steel before tapping results in better rolling qualities and greater freedom from objectionable inclusions.

Low-Carbon Ferrochrome Produces Better Chromium Steel— The lower carbon content of low-carbon ferrochrome as compared with high-carbon ferrochrome inhibits the formation and segregation of hard chromium carbide areas in chromium steel. A more uniform steel results.

Low-Carbon Alloys Save Time and Money — Low-carbon alloys, such as low-carbon ferrochrome and ferromanganese, offer a number of advantages over the higher-carbon grades, especially when increased amounts of scrap are used, resulting in higher carbon in the bath. Oxidation of the bath need not be so severe. The metal loss is decreased. Refractory costs are lowered. Valuable minutes of furnace time are saved. Furnace production is increased. Recovery of the alloying elements is appreciably higher.

• • •

If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

Electromet
Trade-Mark
Ferro-Alloys & Metals

Available through offices of Electro Metallurgical Sales Corporation in Birmingham, Chicago, Cleveland, Detroit, New York, Pittsburgh, and San Francisco. In Canada: Electro Metallurgical Company of Canada, Ltd., Welland, Ont.

PRODUCTS OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

ature. Decreasing the carbon content increases the deformation tolerance, raises the critical cooling rate, and decreases the magnitude of the volume change during the austenite → martensite transformation.

Another type of cracking is peculiar to the welding of thin tubing and sheet in aircraft structures. The cracks follow the boundaries of the austenite grains and may be of any length up to an inch or more. The cracks may open so as to be plainly visible, or may be difficult to detect with a magnifying glass.

The factors that may influence this type of cracking are the composition of base metal, steel refining practice, and previous heat treatment to relieve stresses in cold-drawn tubing. Resistance to grain growth is coupled with insensitivity to cracking; low critical point is favorable to control of cracking; thickness if reduced in the range 1/8-0.04 in. increases cracking tendency; rigidity and complexity of joint increase cracking. Several tests for determining crack sensitivity of base metal are noted.

Cracks relieve shrinkage stresses almost completely, but stress-relief heat treatment will of course not heal cracks that occurred before the part reached heat-treating temperature. Welding of sensitive or moderately sensitive steels at winter temperature is a prevalent cause of hard cracking which may usually be prevented by allowing the part to come to normal room temperature. WB (2a)

Austenitic Welding Rod

"DILUTION OF AUSTENITIC WELDS BY MILD STEELS AND LOW ALLOYS." R. DAVID THOMAS, JR. & K. W. OSTROM (Arcos Corp.) *Welding J., N. Y.*, Vol. 20, Apr. 1941, pp. 185s-189s. Research report.

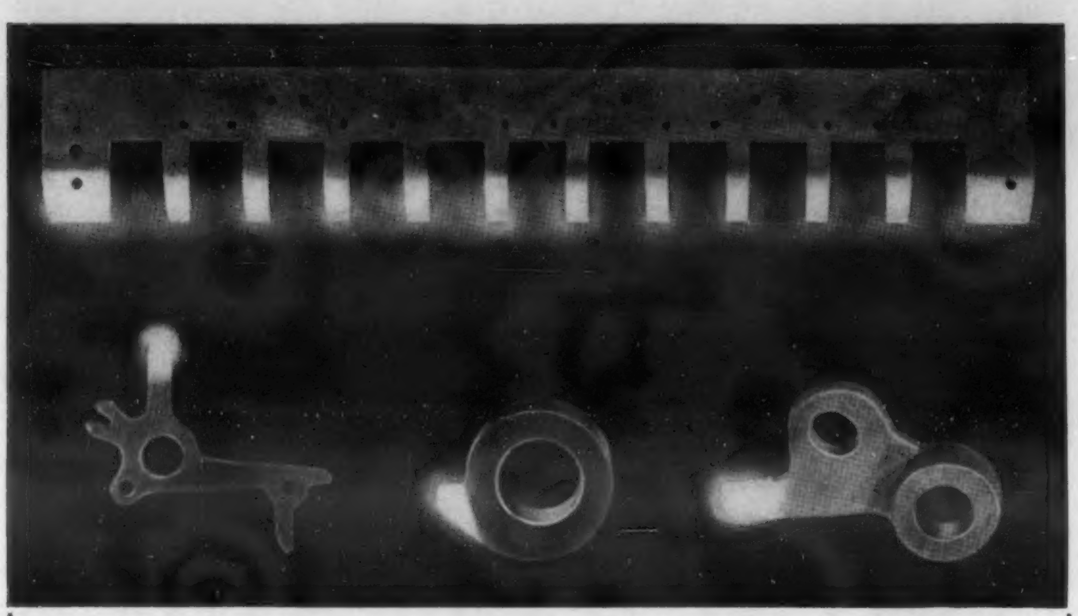
The welding of dissimilar metals such as stainless steel and unalloyed or low-alloy steels with austenitic welding rods presents problems in the unknown and variable composition of the weld metal resulting from dilution with fused base metal or pick-up of carbon from the base metal.

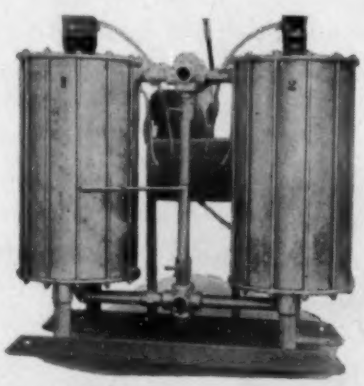
The authors used a standardized technique of building up pads of weld metal on dissimilar base plate with 19-9 and 25-20 chromium-nickel steel welding rod. The pads were built up to at least 3/8 in. above the base plate and the layers analyzed every 1/16 in. from 1/32 in. below the base plate surface by preparing chips with a milling cutter for each successive depth. The data are tabulated and plotted to show the percent influence of the base metal in diluting the weld (or in carbon pick-up) *versus* the height of weld deposit above base metal.

When plotted on semi-logarithmic paper the curves are practically straight lines and by extending them to intersect the 100% influence line it is possible to determine the distance below the parent metal surface to which the weld metal theoretically affects the composition of the base plate. By extending the lines in the opposite direction the graph indicates that it is theoretically impossible to obtain weld metal entirely free from the influence of a dissimilar base metal composition.

It can, however, be determined at what height above the base plate the weld metal may be considered essentially free from contamination. The total concentration of the element and the expected accuracy of the chemical analysis of the element under investigation determine the distance from the base plate.

With the data on weld metal pads as preliminary information, tests were made





on butt welds of various designs, which were made in mild steel plates with a 19-9 chromium-nickel steel electrode. Analyses for chromium were made at various points and the amount of dilution computed on the assumption that the highest chromium content found represented undiluted weld metal.

For a 45° butt weld with ½-in. root spacing in ¾-in. thick plate, the maximum dilution represented a loss of 49.5% of the chromium from the weld deposit. For a weld made by depositing one layer of 19-9 on the scarves before butt welding in the same manner as previously, the maximum dilution was a 12.5% loss of chromium and the lowest value was 2.35%.

With two layers of 19-9 deposited on the scarves before welding with a 60° included angle the maximum dilution was 13.13%; a lowest value of zero dilution was obtained with a chromium content of 18.8% in the sample taken. With a wider root spacing and use of two layers of 19-9 on the scarves the maximum dilution was 4.05%.

With a stainless steel backing strip and other conditions the same as the previous test, the maximum dilution was finally reduced to 1.53% loss of chromium with a chromium content of 18.63%. WB (2a)

Heat Distribution and Weldability

"Mathematical Theory of Heat Distribution during Welding and Cutting." Daniel Rosenthal (Mass. Inst. Technology) *Welding J., N. Y.*, Vol. 20, May 1941, pp. 220s-234s.

This paper is an enlarged translation of a French paper written by the author in 1935. More space has been allowed for practical applications and a new section has been added on the theory of torch cutting. For the sake of convenience, mathematical developments have been placed in an appendix.

The complexity of the mathematics for solving the equation resulting from a consideration of the moving heat source of the arc is simplified by considering only the quasi-stationary state where the heat effects are practically parallel with the weld. Further simplification is carried out by the author by mathematical manipulation and a few assumptions which serve for a first approximation in arriving at the solution of the equations.

The derived formulas for heat flow are applied to a study of the distribution of temperature in the electrode due to the welding arc, and give the following laws: (1) The heat-affected zone in the electrode decreases as the current intensity decreases; (2) the extent to which the electrode is influenced by the heat generated from the arc is very limited and seldom amounts to more than 1 cm.; (3) the heat supplied to the solid part of the electrode represents only a small fraction (less than 20%) of the heat generated by the arc and about 65% goes into the welded plate assuming other losses to be 15%.

The formulas are next applied to welded pieces for which the solution to the equations is put into several graphs of exceptional value. Among these graphs is one giving the cooling velocity as a function of current intensity, welding speed and preheating temperature in thick plates, from which can be determined the lowest temperature to which the metal (steel) has to be preheated prior to welding in order to avoid the danger of hardening.

The graph has been drawn for plain carbon steels, for which a constant value of thermal conductivity and heat input has been assumed. These values are different

when alloying elements are added and the critical cooling velocities are modified to an even greater extent. [*It should, however, be possible to provide such graphs for each alloy addition with constant carbon, or vice versa.—W. B.*]

The author considers the term "weldability" to be meaningless as applied to the ease of welding steels without the production of a hard, martensitic, heat-affected zone, since it depends on all the factors which govern the heat distribution, and primarily on the rate of cooling during welding. To show the dependence of weldability in the above sense on (a) current intensity and (b) welding speed, the author gives 2 sets of curves in which Brinell hardness and cooling velocity have been plotted against (a) and (b) for a 2-in. section of a 0.44% C steel.

A decrease in welding speed or increase in current intensity decreases the hardness attained and the cooling velocity thus indicates the conditions under which the metal is weldable. From the formulas a rule results, which shows that preheating is more effective in lowering the rate of cooling than is decreasing the welding speed or increasing the current intensity.

The mathematical study of oxygen cutting leads to a summary of the effect of various factors on drag. The favorable factors tending to decrease the length of drag are increase of jet pressure and preheating temperature of the specimen, while the unfavorable factors are increasing speed, size of tip and alloying content.

In a comparison of cooling velocity during cutting with that during welding, it is stated that as a rule the cooling conditions during cutting will be more drastic than during welding since cutting speeds are generally 4 to 5 times as great as welding speed. An analysis of the economics of cutting indicates that the cost can be reduced by approaching a maximum drag value. However, by increasing the pressure and preheating temperature, lower drag values consistent with satisfactory cuts can be made at lower cost.

Speed appears to be an uneconomical factor, based on the formulas considered. The cost of preheating must be considered in any statement of overall economy in its use. WB (2a)

Welding Chromium-Moly Pipe

"The Weldability of 4-6 Chromium—½% Molybdenum Steel and Its Application to the Piping Industry." R. W. Emerson (Pittsburgh Piping & Equipment Co.) *Welding J., N. Y.*, Vol. 20, May 1941, pp. 239s-248s. Review plus research.

The literature is reviewed on the rate of transformation at constant, subcritical temperatures, and the extreme sluggishness of the reaction is noted for this type of steel.

Steels capable of full hardening have high propensity for building up large internal stress, and for cracking, therefore the 4-6% Cr, ½ Mo steel requires close metallurgical control for crack-free welds. Cracks usually appear at the root of the weld after the first pass.

Stress relief at 1350°F. of welded joints with martensite in the heat-affected zone produced spheroidized carbide in this zone. A number of welds made with the metallic arc on 10¾ in. O.D. pipe with ⅜ in. wall were surveyed for hardness, microstructure and physicals in these 4 conditions: (1) no preheat or stress relief; (2) no preheat, but with stress relief; (3) with preheat, but no stress relief; (4) with both preheat and stress relief. Comparisons were made with atomic-hydrogen welds in same material.

Cooling rates were shown to increase in the order atomic-hydrogen; arc weld, with 600°F. preheat; arc weld with no preheat. Tentile test and bend test results indicate that the best properties are attained by pre-heating plus stress relieving. The bend tests on atomic-hydrogen welds showed extremely brittle welds, which, however, had excellent ductility after stress relief.

The problems of deposition of sound weld metal with the 4-6% Cr electrodes are discussed, and the opinion is given that the use of preheat and higher welding current aid in elimination of porosity. It is necessary to maintain a large pool of weld metal and a highly fluid slag to achieve successful welding; however, this practice is incompatible with the conditions required for vertical and overhead welding, and these should therefore be avoided as much as possible. Similarly the atomic-hydrogen arc, which operates with a relatively large pool of weld metal, is therefore not suited for vertical or overhead welding.

It is considered essential for sound, ductile welds in 4-6% Cr-Mo steel to preheat to 550°-650°F., weld with high current, stress relieve at 1350°-1375°F. or heat to 1550-1600°F. Preheating prevents cracking of welds and when used without post-heating will produce sound welds of high strength, but lacking in ductility. The post-heat-treatment restores ductility.
WB (2a)

Machining Stainless Steel

"When You Machine Stainless." W. B. Brooks. *Am. Machinist*, Vol. 85, July 9, 1941, pp. 643-644. Practical.

Stainless (18-8) steel has a high coefficient of expansion as well as low thermal conductivity; therefore, adequate lubrication with sulphur or sulphur-chlorine-bearing cutting fluids should be used. Tool angles should be such as to keep down friction (and consequently excessive heat generation) and to avoid work hardening.

Back and side rake and relief should be increased; cutting angles on lathe tools decreased. A rake of 15-20°, side rake of 5-10°, and front and side relief of 5-10° have been found satisfactory. Tools should be sharp to avoid work hardening; honing after grinding is recommended.

A generous feed and cut below the work hardened surface of the preceding cut should be used. Cutting speeds should be 20-50% lower than those used on machine steels.

Sulphur, phosphorus or selenium addition to the steel improve machinability because of their "anti-welding" properties. [A new free-machining addition to stainless steel is bismuth, as reported in a digest on "Free-Machining Stainless Steels Containing Bismuth," in Digest Section 3a of this issue.—Editors] Cold drawing improves machinability by reducing the ductility of steel. JZB (2a)

Making a Gage to Maximum Accuracy

"A Master Taper Gage Is Produced." *Western Mach. & Steel World*, Vol. 32, June 1941, pp. 276-278. Practical.

A 2% C, 13 Cr, 1 V steel was forged down to a tapered blank ¼ in. larger than finished dimensions. After annealing, the gage was rough-machined to within 0.020 in. of final size.

The part was then heat treated by packing in spent carburizing compound, slowly heating to 1550° F. and holding for 2 hrs., heating to 1800° F. and again soaking for 2 hr., then oil-quenching, temper-

ing at 385 F. for 2 hr. and allowing to furnace cool. The gage was "seasoned" by repeating the same tempering treatment each day for the next 7 days.

After finish-turning, the gage was ground. The grinding operations were carried on over a considerable length of time—that is, after taking a few passes of the wheel across the gage, the piece was laid aside for a few days before further work was done. In this way, the master gage was finished with the greatest possible accuracy of size. JZB (2a)

2b. Non-Ferrous

Welding Tungsten, Tantalum, Molybdenum and Related Metals

"WELDING TUNGSTEN, TANTALUM, MOLYBDENUM AND RELATED METALS. A REVIEW OF THE LITERATURE TO JULY 1, 1939." W. SPRARAGEN & G. E. CLAUSSEN. *Welding J., N. Y.*, Vol. 20, Apr. 1941, pp. 161s-166s. Correlated abstract; 62 references.

Fusion welding of tungsten is difficult, except with atomic-hydrogen arc, since it forms a gaseous oxide above 1300°F., and reacts readily with carbon above 2000°F. The welds are usually brittle due to recrystallization and grain growth.

Carbon-arc welds can be made on tungsten in an atmosphere of nitrogen and hydrogen. Resistance welding can be applied to joints in tungsten, or between tungsten and high-copper alloys, molybdenum or nickel.

Tungsten can be brazed to other metals by means of copper with or without 2% Si or nickel addition. Tungsten is wetted by copper and when prepared with a copper surface can be silver-brazed or soft soldered to other metals.

Tungsten may be coated with platinum by means of platinum chloride coating and then can be welded to platinum. Tungstates are considered to be solvents for tungsten oxides and have been recommended as fluxes.

Tungsten carbides as tool bits are brazed or silver soldered to steel tools by the furnace method using the joining alloy as a foil between the tool and tungsten carbide tip. A flux containing fluorine is preferred to borax. It may in certain cases be desirable to electroplate carbides containing titanium or tantalum with nickel before brazing. The best steels for tool shanks in the order of preference are, (a) 0.55% C, 0.85 Mn, 0.30 V, 2.10 Si, 0.25 Cr, (b) S.A.E. 2340; (c) any low-alloy steel with 0.40-0.60% C.

Welds in tantalum are made by fusion in the absence of air or hydrogen. Absorption of hydrogen by tantalum is a peculiar property since in cooling from 1800°F., in hydrogen it will absorb 700 times its own volume of the gas. Oxidation in air or steam occurs at 750°-1100°F. and carbides are found above 2200°F. Fusion welding of tantalum must thus be done in vacuum, under water or under carbon tetrachloride.

Tantalum parts can be resistance- or spot-welded under water. Good welds can be made between tantalum and iron, nickel and aluminum, but welds between tungsten and molybdenum are difficult to make.

Welds in molybdenum are also difficult due to its volatile oxide, and to the brittle, coarse grain developed. Spot welding of molybdenum to other metals can be successfully accomplished as reported for tungsten and nickel wires and with careful control for tantalum, iron, copper, aluminum, Invar, Monel, stainless steel, silver, nickel-chromium, manganin, "nickel-silver," nickel-plated brass, etc. Excellent spot welds of molybdenum to molybdenum sheet can be made by inserting a thin strip of zirconium between the sheets.

Atomic-hydrogen torch and carbon-arc with hydrogen atmosphere are successfully used for the fusion welding of molybdenum. The silver soldering of molybdenum can be accomplished by fusing sodium nitrite ($NaNO_2$) to react with molybdenum and thus melt the silver, which wets the molybdenum surface.

Stellite can be oxyacetylene welded with a reducing flame, also with atomic-hydrogen, metallic- and carbon-arc. Copper brazing can also be applied. Resistance butt-welding or flash-welding are successfully applied to the tipping of steel tools. WB (2b)

Cleaning Aluminum for Spot Welding

"PRECLEANING AIDS SPOT WELDING OF ALUMINUM." C. D. SMITH (Oakite Products) *Iron Age*, Vol. 147, June 5, 1941, pp. 52-54. Practical.

Several techniques have recently been developed for chemically cleaning aluminum alloys. Two general methods are available for preparing aluminum for spot welding: mechanical means, such as steel wheel brushing, and chemical cleaning.

The most common aluminum alloys used in the aircraft industry are 24S (4.5% Cu, 0.6 Mn and 1.5 Mg) and 52S (2.5% Mg and 0.25% Cr). The precleaning methods developed are known as matte finish and mill finish. For the matte finish an alkaline etching bath is used, while for the mill finish an acid type.

Both methods require a preliminary cleaning if the work is very oily. The matte finish is preferred for non-Alclad copper-bearing aluminum alloys. It produces a fine-grain uniform etch, which is advantageous if the part is to be painted.

The aluminum part is first cleaned with a special "aviation" cleaner followed by a cold rinse. The part is then immersed in an etching bath, rinsed and given a short immersion in cold 50% by volume nitric acid to remove black copper oxides. After the final rinse, the part is ready for welding. If soft water is used, drying is not necessary.

For the mill finish, the preliminary cleaning is the same as above. A non-etching type of solution is used for oxide removal, followed by a rinse.

The equipment consists of a series of tanks made from welded black iron. The nitric acid tank requires an acid-proof lining. For the mill finish iron tanks may be used for both precleaning and rinsing. For the etching solution, tanks may be of cypress or Douglas fir.

Chemical cleaning methods have many advantages over manual mechanical methods: (1) More welds can be made before the electrodes have to be cleaned; (2) more uniformity is obtained when the whole area is treated the same; (3) parts inaccessible to wire brush may be cleaned; (4) the cost is lower; (5) there is lower solution/unit cleaned; (6) the danger of excessive brushing is eliminated; (7) greater consistency and soundness of welds are obtained; and (8) assemblies may be more easily cleaned. VSP (2b)

Welding Copper and Red Brass

"WELDING OF COPPER AND RED BRASS." J. J. VREELAND & J. BABIN (Chase Brass & Copper Co., Inc.) *Welding J., N. Y.*, Vol. 20, Apr. 1941, pp. 219-225. Experimental.

Most of the trouble encountered with copper welding has been due to the use of electrolytic copper or other copper containing oxygen. The welding of copper that contains oxygen is restricted to methods that do not involve a high percentage of reducing gases.

The carbon arc is excellently adapted to the welding of oxygen-bearing copper, using a phosphor bronze filler metal. The use of 3% Si rod gives lower properties because of the lower welding speed required to assure sound weld metal. Satisfactory tensile properties are obtained with the carbon arc and phosphor bronze rod but the ductility is erratic.

The carbon arc welding of deoxidized copper is accomplished by slightly preheating and using an arc of at least 50 volts while welding; the result will be high-strength welds with acceptable ductility. The 3% Si bronze rod is considered superior for this class of welding.

For oxyacetylene welding of electrolytic copper the tensile strength is low (approximately 18,000 lbs./in.^{2}) but with the use of phosphorus-deoxidized copper and deoxidized copper rods containing 1% Ag values of 25,000 lbs./in.^{2} are obtained. The rods are too fluid for heavier gages of copper than 3/16 in. and rods containing 0.15 to 0.3% Si are used to replace them for thick copper sheet. The silicon-containing rods can be used also in vertical and overhead welding and will develop 27,000-30,000 lbs./in.^{2} in hot-rolled copper sheet having an average tensile strength of 32,000 lbs./in.^{2}

Red brass (85% Cu, 15 Zn) is successfully welded with the torch using a low-silicon bronze rod containing 1.5% Si, 0.25% Zn, and balance copper, which produces a deposit that is not subject to failure by dezincification as are deposits from yellow brass brazing rods. Carbon arc welding is successful if the 3% Si, balance copper type of rod is used. WB (2b)

Electropolishing Nickel-Plate

"THE ANODIC POLISHING OF ELECTROPLATED NICKEL." A. W. HOTHERSALL & R. A. F. HAMMOND. *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 83-98. Descriptive.

By the anodic polishing of dull electroplated nickel in an electrolyte of sulphuric acid, a surface can be obtained having as high a reflectivity as mechanically polished nickel. This process may be an alternative to "bright nickel" plating and can be used to produce matte designs by protecting part of the surface.

The operating conditions are not critical. The electrolyte consists of 73% H_2SO_4 by weight (600 cc. concentrated acid + 400 cc. water), although a concentration as low as 60% can be used. The satisfactory temperature range is 70°-100° F. and the current density should be 150 to 300 amp./ft.^{2} Lower current densities may cause pitting.

At temperatures below 70° F. a high voltage is required and nickel salts may crystallize out on the anode. The time of

treatment varies from 0.5 to 2.5 min., depending on the conditions of deposition and the thickness of deposit. Best results are obtained with fine-grained nickel deposits and with nickel deposited on well-polished base metals.

The amount of metal removed is between 0.00005 and 0.0002 in. The chief difficulties encountered are streaking and pitting. Gentle agitation of the specimen helps to avoid these difficulties. Streaking may be prevented without recourse to agitation by adding 200 cc. of glycerine or 4 gm. of benzene sulphonic acid to a liter of 73% sulphuric acid. Occasionally the brilliance of the anodically polished nickel is marred by a bloom or fog, the cause of which is not known, but it may be related to the crystal structure of the nickel deposit.

The porosity of nickel coatings 0.001 in. thick is not appreciably increased by anodic polishing, but the porosity of coatings 0.0005 in. may be considerably increased. The polishing treatment removes metal more uniformly than it is plated. This is a disadvantage, as it tends to remove too large a proportion of nickel from recesses where the coating is usually the thinnest.

AB (2b)

Hard-Chromium Plating on Aluminum

Hard Chromium Plating of Aluminum and Its Alloys ("Ein Beitrag zur Hartverchromung von Aluminium und seinen Legierungen") A. Beerwald. *Aluminium*, Vol. 23, Mar. 1941, pp. 149-155. Descriptive.

The adhesion of electroplated coatings on aluminum depends largely on having the aluminum surface free of oxide and somewhat rough. These factors must especially be observed when producing hard-chromium films on aluminum-copper-magnesium alloys.

The denser and more uniform the roughening of the surface, the better is the adhesion. Best results in this direction were obtained by first degreasing in hot caustic soda, rinsing, cleaning in nitric acid, rinsing and then pickling in a saturated solution of crystallized nickel chloride with an addition of 2% HF and 4% boric acid.

For aluminum-magnesium alloys, however, the most suitable pickling bath is a 15% copper chloride solution with an addition of 0.5% hydrochloric acid; the pretreatment is the same as above. The attack of the pickler increases with the magnesium content of the alloy; the pickling time therefore varies from 30 sec. for 9% Mg alloy to 1½ min. for pure aluminum.

The chromium film so obtained did not come off even when subjected to very sudden temperature changes. The chromium hardness on aluminum, measured with the Zeiss microhardness tester (see Metals and Alloys, Vol. 12, July 1940, p. 108), was 1190, while on steel it was 1280.

The hard-chromium plating bath recommended for this purpose contains 320 g./l. CrO_3 and H_2SO_4 in amounts equal to 1.2% of the CrO_3 content. The thickness of the chromium layer is about 0.0007 in. after 1 hr. at a current density of 50 amps./dm.^{2} and 120° F. Recently baths with only 240 g./l. CrO_3 have been shown to give better current efficiency; they can be used for light metals as well provided they contain H_2SO_4 and no other acids. It was found that HF-containing baths are unsuitable for chromium-plating on aluminum, except with extremely high current densities.

Ha (2b)

Design and Applications 3

METALS, ALLOYS, METAL FORMS ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Metallurgical Design of Aircraft Engines

A Composite

The old question of the relative strategic advantages of (a) standardizing military aircraft engine design to the point of having all companies making engines for a particular type of plane manufacture to the same set of specifications and blueprints, or (b) using currently installed tools, facilities and "know-how" to make, without loss of time, a variety of engine-designs is again moot.

We don't know the answer, but we do know that there is no such thing as fixed design with respect to the metals and metal-forms used for engine components, as shown by 3 recent articles in which engine design and production practice are broadly reviewed.

The materials and manufacturing processes used for Wright cyclone engines are outlined by P. W. Brown of Wright Aeronautical Corp. ("Wright Turns to Fine Production," *Am. Machinist*, Vol. 85, June 25, 1941, pp. 595-618).

The crankcase is a forging—a chromium-moly steel forging for double-row 14-cylinder Cyclone engines and an aluminum alloy forging for single-row Cyclones. The steel crankcases are machined with high speed steel tools, and the aluminum crankcase with carbide-tipped tools.

Nitralloy steel forgings are used for cylinder barrels. To localize the nitriding to the bore of the cylinder, the barrels are tin-plated all over, then the bore is rough-ground internally prior to nitriding. The nitriding operation involves a 10-hr. heating-up period, 35-hr. soak at 1000° F., and cooling to 400° F.

Cast aluminum alloy cylinder heads are assembled to the barrels in the following manner: The heads are heated to 600° F. in an electric furnace, then the valve seats and guides (previously chilled in alcohol and dry ice) are inserted in the head and the barrel is threaded into the head casting. Before the head cools, various bushings are also fitted into it. These operations must be carried out quickly before the head cools excessively.

Cylinder assemblies may be either

Materials in Some American Aircraft Engines

Engine	Cylinder Type	Cooling Type	Crankcase	Cylinder Barrel	Cylinder Head
Aircooled Franklin 4AC-171	4	Air	Aluminum alloy casting	Aluminum alloy, (Y alloy) casting	Cast aluminum alloy. (Y alloy) casting
Akron Funk B	4	Liquid	Aluminum	Cast iron	Aluminum casting
Allied Monsoon	4-in-line	Air	Heat-treated aluminum lower half; magnesium rear half and top covering	Steel forging	Heat-treated aluminum alloy
American S-5-125	5-radial	Air	Aluminum alloy casting	Nickel alloy cast iron	Aluminum alloy
Continental A-75	4-opposed	Air	Aluminum alloy casting	Steel forging	Aluminum alloy casting
Jacobs L-6MB	7-radial	Air	Magnesium and aluminum heat-treated alloy castings	Chromium nickel-molybdenum steel forging	Aluminum alloy casting
Ken-Royce Model 7F	7-radial	Air	Aluminum alloy casting	Steel forging	Aluminum alloy casting
Kinner SC-7A	7-radial	Air	Aluminum alloy casting	Steel forging	Aluminum alloy casting
Lenape Brave	5-radial	Air	Magnesium casting	Hardened alloy steel forging	Aluminum alloy casting
Lycoming R-680-E Series	9-radial	Air	Heat-treated aluminum alloy casting	Carbon steel	Aluminum alloy
Menasco Buccaneer	6-inverted in-line	Air	Aluminum alloy casting. Magnesium cover plate	Nickel cast iron or S.A.E. 3140 steel	Aluminum alloy casting
Monocoup Lambert R-266	5-radial	Air	Magnesium alloy	Nickel iron casting	Heat-treated aluminum alloy
Pratt & Whitney Twin Wasp	14-radial	Air	Forged aluminum alloy nose section. Cast magnesium blower and accessory section	Chromium molybdenum steel forgings	Aluminum alloy casting
Ranger SGV-770B	12-60° Vee	Air	Aluminum alloy casting	Steel forging	Aluminum casting
Skymotors 70A	4-inverted-in-line	Air	Aluminum alloy	Aluminum alloy casting	Aluminum alloy casting
Warner Super Scarab 165	7-radial	Air	Heat-treated aluminum alloys	Alloy steel	Heat-treated aluminum alloys
Wright Double-Row Cyclone 14	14-radial	Air	Aluminum alloy forging	Nitrided steel	Aluminum alloy casting

specialized knowledge of steel

Service will help you

RIGHT now a little information can be mighty valuable. Whether you are working on defense orders or are trying to meet the demands for domestic consumption, you can't help but be aware that the steel picture is changing rapidly. Especially is this true of alloy steels where a new resourcefulness has been required to meet admittedly difficult situations.

As a result, less familiar but not unproved alloying elements are being increasingly employed. Of these, certain elements which have been growing in use steadily during the past decade are now apparently destined to play an ever more dominant role.

Facts like these—and the urgent demands for production today—call for a re-examination and re-orientation of your alloy steel set-up. It may make imperative some revision of shop practices. It means that new methods of doing some jobs must be discovered.

Here's where the specialized knowledge of our metallurgical contact staff can help you. These men know metals. They are working right on the firing line where the smoke of production is thickest. They are prepared to help you work with the materials available. And they can help you make the most efficient use of existing plant facilities. It's a tough job to work out alone—we'll be glad to cooperate on it.

CARNEGIE-ILLINOIS
STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

USS

CARILLOY *Dependable* ALLOY STEELS

bonderized and painted or shot-blasted and metallized with pure aluminum with a spray gun.

The crankshaft in the double-row Cyclone-14 engine has more than 30 parts, 4 of which are bronze castings and the rest steel forgings. The crankpin bore and the knuckle pin bores in the master connecting rod (made of a steel forging) are hard-chromium-plated.

A steel-backed copper-lead bearing is used in the main bearing bore, and a bronze bushing in the piston pin hole. Bronze bushings are also used in the knuckle pin and piston pin holes of articulated rods.

About ¾ of the gears are made from S.A.E. 3312, and the rest from Nitralloy. All forgings are normalized before machining (which is done mostly with carbide tipped tools). S.A.E. 3312 is carburized to give 0.025-0.035 in. depth of case with a Rockwell C 60 case hardness.

A recent article on machining practice in the manufacture of Ranger 6-cylinder in-line direct-drive engines for Army Air Corps training planes ("Power for Army Trainers," *Am. Machinist*, Vol. 85, May 28, 1941, pp. 488-502) gives many incidental data on materials used. The main crankcase is made of heat-treated cast aluminum alloy, and all its parts are zinc-chromated and baked as a ground coat for painting.

Some of the other material-specifications are as follows:

- crankcase bearings: bronze-backed babbitt-lined
- camshaft: heat treated alloy steel forging
- camshaft housing and cover: magnesium alloy
- cylinder heads: cast aluminum alloy with integral fins
- valve seats: aluminum bronze
- valve guides: bronze
- cylinder barrels: chromium-moly steel forgings, fins integral
- I-section connecting-rods: aluminum-moly steel forgings
- main connecting-rod bearings: steel-back cadmium-silver bearing shells
- piston pin fit of rods; bronze bushings
- pistons: aluminum alloy
- wrist pins: heat treated alloy steel

In another article—this time on finishing, by M. A. Coler ("Aircraft Engine Finishes," *Metal Finishing*, Vol. 39, Feb. 1941, pp. 115-117), a table is presented of the metals and metal-forms used for crankcases and cylinder exteriors of 17 American aircraft engines. This table, prepared from data appearing in *Aero Digest's "6th* Annual Digest of Aircraft, Engines and Accessories" is reproduced herewith. X (3)

Plastics for Metals

A Composite

This war is a fearsome thing, but the real Armageddon is going to be the battle for material-consumption markets—lost, new or miraculously held—that is certain to occur when the military conflict is history. And right in the center of it will be the battle between various individual metals essential to defense and the materials—plastics, notably—that have at least temporarily usurped them for certain products.

The situation with respect to the substitution of plastics for metals has been examined in a series of editorials in the March, April and May issues of METALS AND ALLOYS, which in general (a) urged metal producers and users to cooperate in their own and the country's interest to achieve metal-saving substitute designs, (b) respected the right of plastics to gain permanent replacement in some cases, and (c) mumbled a few prayers against the melée that is to follow.

The Immediate Situation

A running review of the extent to which plastics have eased the metal-supply situation in individual cases and a description of numerous industrial and consumer products in which plastics have replaced metals is given by J. DELMONTE of Plastics Ind. Tech. Inst. ("Plastics Conserve Metals for Defense," *Machine Design*, Vol. 13, May 1941, pp. 31-34). He reports that at the time of writing activity in plastic molding alone is over 50% greater than a year ago with many new designs and changes still in the drafting-board stage.

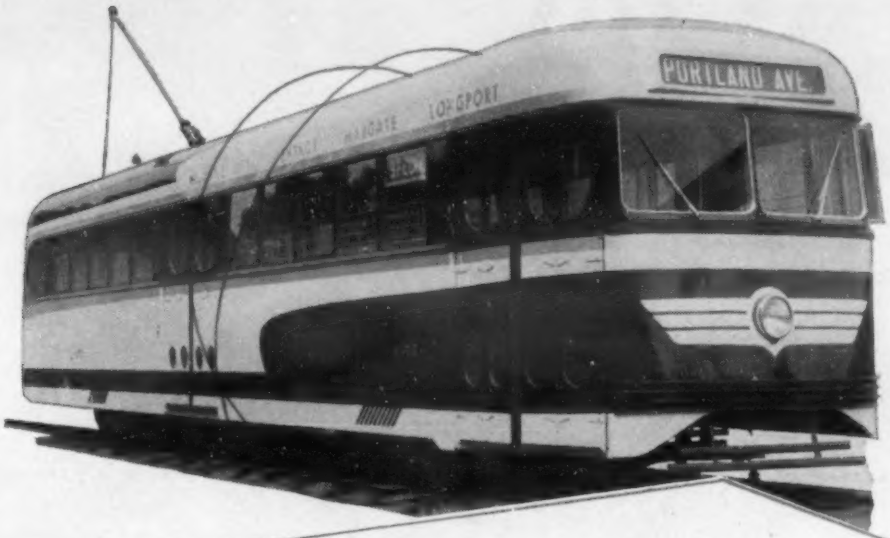
One auto manufacturer reports that 5 lbs. of zinc will be saved on each car in the re-designed models using a greater amount of plastics. Training type aircraft, too, are expected to be made of plastic-bonded plywood to conserve aluminum and magnesium for fighter craft.

But the heavy replacement is occurring in the fields of household equipment, hardware and electrical products. Vacuum cleaner nozzles and hose fittings, motor housings, refrigerator trays, business-machine cases, etc. are among the products for which metal-design engineers are switching to plastics.

Where aluminum and magnesium die castings are to be replaced by plastics, the design engineer familiar with the importance of proper draft, generous radii, adequate wall thickness, etc. will have little

The "BRILLINER"

the new type car for Atlantic City



DUCTILITY
ITS INHERENTLY FINER GRAIN MAKES ALL THE DIFFERENCE
STRENGTH

built stronger, lighter . . . with

N-A-X

High Tensile

The "Brilliner" is a new type fast, quiet, light-weight street car built by the J. G. Brill Company for the Atlantic City and Shore Railroad. The car is made of rolled sections and plates rigidly welded and riveted together. Plates and sheets over ⅛ inch thick are mild open hearth steel, while sheets ⅛ inch thick or less are N-A-X HIGH TENSILE, the low alloy steel with unusually high resistance to IMPACT, STRESSES, SHOCKS and FATIGUE.

N-A-X HIGH TENSILE has other important properties, too, that have won wide acclaim from both fabricator and user. They are: unusual ductility, high yield point, high ultimate strength, and marked resistance to corrosion and abrasion. It can be welded readily, easily, by any one of the standard approved methods. Then, too, it can be fabricated by all regular shop routines—in most cases no "change-over" is required.

Do as hundreds of others are—cash in on the profit-making advantages of N-A-X HIGH TENSILE. A Great Lakes engineer will be glad to call at your convenience and give you the benefit of his knowledge of the use of N-A-X HIGH TENSILE in many hundreds of applications. Or, write for full information today.

LIST OF PRODUCTS

Hot Rolled Strip (down to 1 inch wide) . . . Hot Rolled Strip Sheets (up to 91 inches wide) . . . Spring Steel (carbon and alloy) . . . Merchant Bars . . . Forging Bars . . . Automobile Bumper Sections . . . Bar Mill Sections . . . N-A-X HIGH TENSILE Bars, Shapes, Sheets, Billets . . . Sheet Bars . . . Hot and Cold Rolled Sheets . . . Michigan Metal for Vitreous Enameling . . . Deep Drawing Quality (in all grades, widths up to 91 inches) . . . Stran-Steel Metal Framing for Residential and Commercial Construction.

GREAT LAKES STEEL CORPORATION—DETROIT, MICHIGAN

Sales Offices in Principal Cities

division of **NATIONAL STEEL CORPORATION**

Executive Offices, Pittsburgh, Pa.

difficulty in applying similar principles to designs in plastics. Wall thicknesses will be reduced somewhat and draft or taper must be decreased.

A Look Ahead

A critical examination of some of the optimistic claims made for the future position of plastics is given by HERBERT CHASE ("Can Plastics Replace Metals?" *Am. Machinist,* Vol. 85, June 11, 1941, pp. 527-530). The substitution of plastics for metals must be considered from a general defense viewpoint as to whether increasing use of plastics might not lead to worse bottlenecks than now exist in nickel, zinc, etc.

A few aluminum aircraft parts have been replaced by plastics, but the total effect is not very significant. There might, however, be considerable effect upon the supply of certain plastics for other uses if the plastic-bonded plywood plane (with about 10% resin as "plastic") becomes as large a factor as is sometimes foreseen.

The automotive and electrical industries are now the largest users of plastics. Transparent inclosures for aircraft, etc., are taking a large proportion of acrylic plastic production. A variety of plastic parts are employed in communication and electrical systems used by the Army and Navy. Considerable plastic is also used in gas masks.

The substitution of plastics for metals is confined chiefly to parts that are largely decorative or lightly stressed in service, although exceptions are aircraft parts and gears where the plastic depends largely on wood, fabric, or paper for strength and shock resistance. Almost always a lengthy period of experimentation is required before the change can be made. Often, as in the case of the Ford plastic body shells, the plastic has been discarded after long trials because of brittleness, warpage, shrinkage, or cold flow.

However, plastic has successfully replaced aluminum alloy castings for washing machine agitators. There has been almost no substitution of plastics for external die castings, although it has been satisfactorily used to replace internal zinc alloy die castings for Ford instrument bezels, etc.

The total production of plastics in 1939 was less than 0.3% of steel production on a tonnage basis. The chances for large-scale substitution for zinc alloy are not promising, because much zinc is used in brass, external die castings, and galvanizing. The possibilities for substitution for aluminum are better.

Although there has been no marked shortage of raw materials for plastics, most producers are already producing near capacity. The widespread adoption of plastics would also involve obtaining more molding machines, molds, and skilled diemakers, all of which are now at a premium. X(3)

Metal Spray for New Products

"DO YOU REALIZE THE IMPORTANT POSSIBILITIES OF METAL SPRAYING IN REPETITIVE PRODUCTION WORK?" W. C. REID (Metallizing Eng. Co., Inc.) *Steel,* Vol. 108, Apr. 14, 1941, pp. 52-53, 87-88, 90. Descriptive.

Metal spraying shows much promise as a production tool for obtaining hard wear-resistant cylindrical surfaces. All variables in the operation of a spray-gun are under precise control; automatic and semi-automatic operation are feasible. Hardness up to 450 Brinell is easily produced on wearing surfaces.

The largest field for production metal spraying at present is on shafts of exceptional size, piston-rods, and similar work where costs might be prohibitive if the hard surfaces needed were produced by heat treatment or by making the entire object of hard alloy steel.

The only new equipment now incorporating metal spraying in its production is the rods of piston pumps, but the process could be used on many bearing surfaces of trucks and other heavy automotive equipment; bearings and throws of crankshafts of heavy Diesel and similar engines; valves, especially very large plug valves (24 in. or so); valve stems of Diesel and automotive engines; revolving electric equipment; all bearings of machine-tools; very large axle shafts; gun mounts; hydraulic rams of gun recoils; etc.

The process is economical, and permits the production of a hard and corrosion resistant surface in one operation. The total cost per hr., excluding overhead and burden, varies from 0.37c/lb. of metal sprayed for medium- or high-C steel to $1.07/lb. for nickel. Effective mechanical bond is easily obtained by first grooving the base surface in a lathe with a special grooving tool; abrading the top surfaces and spreading them out to form positive interlocking pockets; and spraying the first few coats of metal at a 45° angle alternately from one side to the other.

Inherent porosity and low coefficient of friction of sprayed metal make it very advantageous for bearing surfaces (see METALS AND ALLOYS, Vol. 12, Sept. 1940, p. 346). Tests indicate that the porosity is responsible for absorption of lubricant

and a 20-25% decrease in coefficient of friction, with resultant reduced wear and greatly increased service life and seizure loads.

Any commercial metal can be sprayed with modern equipment. The total thickness of deposits is not limited; the most acceptable and most widely used practice limits the thickness per pass to 0.032 in. Dissimilar metals can be applied one to another, if the surface is properly prepared, and metals can be sprayed on nonmetals, if these surfaces are of a naturally porous nature. MS (3)

3a. Ferrous

Advantages of Mild Steel

"MILD STEEL." H. A. DICKIE. *Metal Treatment,* Vol. 7, Spring, 1941, pp. 19-24. Survey of modern practice.

This short article, written by a metallurgist connected with the new basic Bessemer plant at Corby, emphasizes that in its particular fields ordinary mild steel has advantages over any alloy steels. Its weldability is a particularly valuable feature and enables continuously welded tubes to be made by the Fretz-Moon process that have extremely high ductility and toughness and are free from any high temperature transformation structure.

The total impurities (allowing for iron and manganese in combination with carbon, sulphur, oxygen, etc., but excluding manganese in solution) vary from 1.4 to 2.0% for open hearth steels, 1.2% for acid Bessemer steel, and 1.0% for basic Bessemer.

By a new technique, involving the operation of a basic converter by means of two slags, a special deep-drawing steel, very free from stringers and similar inclusions, and containing only 0.7% impurities is being produced. The steel contains less than 0.03% C.

It is emphasized that the yield point and elastic limit of mild steel can be tripled by severe cold working followed by low temperature heat treatment.

JCC (3a)

Free-Machining Stainless Steels Containing Bismuth

"ADDITION OF BISMUTH FOR PRODUCING FREE-MACHINING STAINLESS STEELS." H. PRAY, R. S. PEOPLES & F. W. FINK (Battelle Mem. Inst.) *Am. Soc. Testing Materials,* Preprint No. 29, June 1941, 10 pp. Research.

The addition of small amounts of bismuth (0.1-0.5%) to stainless steels results in a remarkable and useful increase in their machinability, with no detriment to their corrosion resistance. In some cases the latter is actually improved.

Sawability and drillability tests of the type previously described by Nead, Sims & Harder (METALS AND ALLOYS, Vol. 10, Mar. 1939, p. 68; Apr. 1939, p. 109) were made on cast 25 Cr, 12 Ni and 19 Cr, 9 Ni alloys as reference materials and on similar castings to which sulphur, selenium, molybdenum, phosphorus, copper, silver, lead and bismuth—alone or in combination—were added.

Sulphur or selenium, of course, improved machinability, but affected corrosion resistance to a degree not admissible in this investigation. Silver gave erratic results, possibly due to difficulties in properly incorporating it in the melt. Lead was helpful but its introduction entails difficulties.

When bismuth-containing alloys were tested, the beneficial effect of this element on machinability was at once apparent. Plant trials showed it to be entirely feasible to introduce bismuth under commercial conditions—the recovery was usually 0.20-0.30% Bi, whether 1% or 0.5% Bi were added.

Mechanical properties, weldability and corrosion-resistance are not deleteriously affected by bismuth additions. However, the decreased ductility observed in short-time high-temperature (1800° F.) tension tests indicates that care will be needed as to the *type* of high-temperature service imposed on such steels, although load-carrying ability appears satisfactory. Hot-working of bismuth-containing alloys must be done at slightly lower temperatures.

Like the lead in the lead-bearing steels, the bismuth is apparently present metallographically as submicroscopically dispersed particles, in addition to a relatively small amount of microscopically visible metallic bismuth particles. The bismuth addition seems to favor the formation of ferrite and to increase carbon solubility.

(3a)

Electrical Contacts

A Composite

The ubiquitous electrical contact is one of a growing list if items in the electrical industries that are now regarded as the special province of the metallurgical engineer. Their selection and application is complicated not only by the scope and variety of consumer and industrial devices into which they are designed, but also by the number of alloys and metallurgical types—precious metals, copper-base alloys, electroplates, powder metallurgy products, etc.—out of which they are made for specific applications.

Today these products are as much "metallurgical" as "electrical." Some of the metallurgical angles involved in their utilization are outlined by J. C. CHASTON ("Metals and Alloys for Electrical Contacts," *Metal Treatment*, Vol. 6, Winter 1940-1941, pp. 143-146). The selection of a contact material should be considered as a separate problem for each of the following broad types of duty: (a) instrument make-and-break contacts which suffer no electrical wear by sparking; (b) medium duty contacts breaking up to about 15 amps.; (c) air-break contactors carrying up to about 100 amps. at 440 v.; (d) heavy duty air-break contacts; and (e) heavy duty oil-break contacts. In addition, sliding contacts and those of special construction need individual consideration.

For instrument work, a hard, non-tarnishing material that will withstand the heating effects of accidental sparking without tarnishing is needed. Of the pure metals, only platinum and gold are tarnish-resistant at all temperatures; rhodium may oxidize if heated about 1650° F., and paladium if heated about 750° F.

Thus, for utmost reliability, rhodium is a close runner-up to platinum and gold, with palladium as a cheaper and slightly less satisfactory substitute. Platinum may be hardened with up to 30% iridium or up to 5% ruthenium without impairing its tarnish-resistant properties; and gold likewise with up to 30% silver.

Silver remains entirely free from oxide films, but its tendency to sulphide tarnishing makes it unsuitable for instrument contacts where utmost reliability is required, especially when very small currents and very low contact pressures are involved. In particular, it must never be used near vulcanized rubber insulation or ebonite.

For medium-duty service, where heavier currents are handled, thin tarnish films have less effect on performance, and fine silver is the most generally suitable material, especially since there is a tendency for silver sulphide to be decomposed by the heating effects of the spark. Failure in such circuits is usually due either to welding by the current surge at make (generally avoidable by suitable arc-quenching circuits) or, in d.c. circuits, to "material transfer," which results in a mound being built up on one contact while a crater forms on the other.

Tungsten resists "material transfer" better than any other material, but is not otherwise a good contact material on account of its tendency to become coated with a high-resistance oxide skin. For air-break contactors, copper, which is widely used, tends to suffer excessive wear through the progressive formation of oxide on the surface.

Silver would be ideal except for its

occasional tendency to weld, and there are indications that silver-nickel, silver-graphite, or some similar powder metallurgy product may be more widely adopted for this application. For heavy-duty air- and oil-break switchgear, silver-molybdenum, silver-tungsten, and copper-tungsten "Elkonites" are widely used to withstand the effect of the arc without burning, melting or excessive oxidation.

The causes of failure of instrument and medium-duty contacts are considered in more detail in another paper by CHASTON ("Materials for Electrical Contacts," *J. Inst. Elec. Engrs.*, Aug. 1941). Dust and dirt films are probably responsible for the majority of obscure troubles with instrument contacts. Apart from the more obvious preventive measures, the use of brightly-polished and very hard contact surfaces, such as are provided by rhodium plating, is sometimes effective in preventing dust particles from collecting and, in particular, from being partially embedded.

The very conflicting literature on material transfer is discussed, with a view to its rationalization, and experiments with many contact materials described. Sticking of contacts is frequently due to the welding action of the current surge at "make"; and the results of measurements of the inherent welding tendency of contact materials are given. Wear tests with various noble metals used in sliding contacts are described. JCC (3b)

New Lead-Base Bearing Alloy

"THE PROPERTIES OF CERTAIN LEAD-BEARING ALLOYS." A. J. PHILLIPS, A. A. SMITH, JR. & P. A. BECK (Am. Smelting & Ref. Co.) *Am. Soc. Testing Materials*, Preprint No. 46, June 1941, 8 pp. Research.

A new lead-base bearing alloy containing about 12.5% Sb, 3 As and 0.75 Sn is described, and its properties compared with those of conventional lead-base and tin-base alloys.

At elevated temperatures, approximating those prevailing in automotive engine bearings, the tensile strength and Brinell hardness of the new alloy are considerably higher than those of the standard lead-base alloy and equal to those of the tin-base alloy. In addition, it retains its higher hardness over long periods of exposure to elevated temperatures, whereas the standard alloys show considerable softening under such conditions.

The rotating-beam fatigue strength and the flexure fatigue strength of the new alloy at room temperature are superior to those of the standard bearing alloys. This superiority is also fully retained at 200° F.

The alloy is easy to cast, retains its composition after repeated remelting, and shows relatively little loss of weight due to drossing. Above 350° F. the alloy is ductile enough to permit shaping as required in certain bearing manufacturing processes. The solidus temperature is 468.5° F. and liquidus temperature 563° F.

The properties of the new alloy indicate that it is superior to the lead-base and tin-base bearing alloys now in general use. There have been several installations of the alloy in automobiles and machinery and no failures have been experienced to date, even after 18 months' service in some cases.

Since tin is a strategic material, the new alloy promises to be of great interest because its use can decrease the amount of tin employed for bearing purposes. (3b)

Testing and Control

4

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Ultrasonics for Flaw-Inspection

"ULTRASONICS—A NEW METALLURGICAL TOOL." C. M. COSMAN (Staff) *Iron Age*, Vol. 147, May 15, 1941, pp. 48-50. Descriptive.

Some of the results achieved with ultrasonics and some of the currently feasible projects of metallurgical interest using ultrasonic waves with vibrations above 17,000 cycles/sec. show good progress mainly in Germany, France and Russia.

The permeability of metals for sound and ultra-sound is great. Fine cracks or impurities obstruct the passage of the waves; sound absorption and reflection takes place. Only the shorter ultrasonic waves indicate the position of faults.

Contacting of the test piece with the sound generator and receiver has been difficult. Solokoff's apparatus is arranged so that a clouded picture of a diffraction grating on photographic plate will indicate a flaw in the material under test.

Newton suggests the possibility of using strong mechanical waves for fatigue testing. Within 1 hr. a sound frequency of 10 Kc will cause 36,000,000 reversals.

Possible uses other than for testing include grain refinement of solidified metals, improvement of the nitriding reaction, increasing speed of solidification of castings, and expediting degassing of melts, etc.

VSP (4)

Thickness Test for Silver Coatings

"B. N. F. JET TEST FOR DETERMINING THE THICKNESS OF SILVER COATINGS." R. A. F. HAMMOND. *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 69-82. Descriptive.

The jet test involves allowing a fine stream of a reagent to impinge on a coating until it is penetrated. The thickness of the coating is obtained from the time required for penetration. Previously, this test has been applied to the testing of nickel, copper, zinc and cadmium coatings.

The reagent used for testing silver coatings contains 250 g. of potassium iodide and 7.44 g. of iodine per liter. The rate of penetration of silver coatings varies about 2% per degree C. At 25° C. 0.0001 in. of silver is penetrated in 5.6 sec. and at 18° in 6.6 sec.

The end-point consists in the appearance of a bright crescent-shaped area of exposed basis metal. Surfaces that have been amalgamated before plating give a black spot at the endpoint.

The rate of penetration of the coating depends on both the potassium iodide and iodine concentrations of the reagent. The rate falls off rapidly as the potassium iodide concentration falls below 250 g./1. The results of the test are correct within about 10%.

AB (4)

Surface Temperature Determined by Infra-Red Photography

DETERMINATION OF SURFACE TEMPERATURES BY INFRA-RED PHOTOGRAPHY ("Bestimmungen von Oberflächentemperaturen durch Infrarotphotographie") W. FISCHER. *Elektrowärme*, Vol. 11, Apr. 1941, pp. 65-68. Descriptive.

A method is described by which differences in surface temperature of about 215° F. can be determined with an error of ± 1°. The surface whose temperature is to be determined is photographed on an infra-red sensitive film either in a darkened room or through a filter that blocks out the visible light.

The degree of blackening on the photographic plate is given by s = log J_o/J, where J is the light intensity passing through a uniformly exposed area, while J_o designates the intensity passing through the general plate film.

J_o is practically constant over the whole plate while J diminishes with increasing temperature. The lowest temperature that will cause sufficient blackening is about 480° F. Photographic data and examples of interpretation and evaluation are given.

Ha (4)

Chromium Plate Thickness

"HOW THICK A PLATE?" R. F. YATES. *Am. Machinist,* Vol. 85, May 28, 1941, pp. 477-479. Practical.

Charts showing the rate of deposit under certain plating conditions and thus supplying an approximation of plate thickness after known time, are useful but not reliable. Special microscopes can be used to measure the depth of plate. However, the plated article must be cut, polished, and etched; moreover, considerable skill is required for preparation and operation. The testing period is comparatively long (15 min.) and the instrument costly (about $300).

A simple method suitable for deposits over 0.0002 in. is the Mesle or chord system. A grinding wheel or flat abrasive is used to cut through the deposit until the base metal is just exposed. The length of cut (C) is carefully measured with a scale; since the radius (R) of the grinding wheel or the part is known, the thickness (T) can be calculated from: $T = C^2/8R$.

This method is simple, requires no particular skill or expensive equipment, and is almost as accurate as the microscope method. Deposits under 0.0002 in. are suitable neither for the microscope nor the Mesle method.

A fairly accurate estimate of thickness can be obtained by dropping concentrated hydrochloric acid on the deposit (temperature should be around 70° F.) and timing the gassing. Each second from beginning to end of gassing is equivalent to one-millionth of an inch.

The Aminco-Brenner "Magne-Gage" can measure deposits from 0.0002-0.025 in. thick with an accuracy of ± 10%, which is quite good. It is based on the decrease in magnetic attraction existing from the interposition of a non-magnetic material between a magnet and a magnetic base. After calibration with non-magnetic coatings of known thickness on steel, the thickness of the chromium (or other non-magnetic coating) can be determined.

The advantages of this method are its speed, and the fact that the material tested is neither marked nor destroyed. The cost is about $150.

Recently special X-ray equipment has been developed to determine thickness and structure of deposit. This method is quite costly, and requires a skilled operator and photographic equipment. JZB (4)

Determining Oxygen in Iron

"THIRD REPORT OF THE OXYGEN SUB-COMMITTEE." *Foundry Trade J.,* Vol. 64, May 1, 1941, pp. 293-295; May 8, 1941, pp. 317-318. Extended abstract.

The following papers are reviewed: a general summary by T. Swinden; "Recent Developments in the Determination of Oxide Inclusions in Pig-iron by the Modified Aqueous Iodine Method" by E. Taylor-Austin; "The Determination of Total Oxygen in Pig-iron by the Aluminum Reduction Method" by E. Taylor-Austin; and "Present Position of the Determination of Oxide Inclusions in Pig-iron and Cast Iron" J. G. Pearce.

From the work carried out since the publication of the original aqueous iodine method, several valuable conclusions were drawn. The solution of manganese oxide as such, during the decomposition of samples by aqueous iodine potassium-iodide cannot be prevented, and hence results on this oxide cannot be obtained at present. Iron carbide, iron phosphide, manganese sulphide and titanium carbide cause no interference in the new procedure.

The modification introduced surmounts the difficulties that had arisen during the more general application of the method originally suggested.

The present procedure has been successfully applied to a series of 45 types of pig iron without further complications; it is therefore believed that the process may be employed for the determination of oxide inclusions in all types of pig iron, excluding alloy irons, and that results for SiO_2, FeO, MnO (existing as manganese silicate) and Al_2O_3 are reliable.

The method adopted for the determination of total oxygen in pig iron was the aluminum reduction method described by Gray and Sanders in the Second Report of the Oxygen Subcommittee (See *Metals and Alloys,* Vol. 10, Sept. 1939, p. 525 LI). The Gray and Sanders' apparatus was employed except that the silica combustion tube of the main furnace was heated by a winding of Kanthal (iron-chromium-aluminum-cobalt) resistance wire instead of Silitrod elements.

The sodium carbonate-citrate treatment, already used in the aqueous iodine method, was applied to the unignited residues from the aluminum reduction method. This procedure successfully removed the hydrolyzed silicic acid, and the results for total oxygen fell considerably. The final figures were in good agreement with those by the latest aqueous iodine process. The aluminum reduction method was therefore modified to incorporate this treatment.

The preliminary percentage figures indicate the following ranges for the various oxides in the pig irons examined: 0.003 = 0.020% SiO_2; 0.009 = 0.045 FeO; Nil = 0.002 MnO; Nil = 0.008 Al_2O_3; 0.017 = 0.060 total oxides; 0.005 = 0.020 total oxygen. The oxides as a whole are similar to those found in steel, but not necessarily of the same order.

They are expressed in this form because the residue representing inclusions from the metal has to be ignited or subjected to chemical oxidation to get rid of graphite. They are almost certainly present in a more complex form, and thermodynamic considerations suggest that the inclusions to be expected in pig iron and cast iron, apart from sulphides, are alumina, silicates of iron and manganese and, under certain conditions, free FeO, MnO or SiO_2.

The calculation of the FeO and MnO content of the residue to silicates, allowing for the FeO in solution checks well with the determined values of SiO_2 in the residue, but this is based on equilibrium conditions. The amount of inclusions present proved to be very small, compared, for example, with the sulphides present.

There appeared to be a lack of relation between the inclusions chemically determined and those visible microscopically. Apart from sulphides, the inclusions visible in pig iron and cast iron are due to titanium, and these are so common that their presence must be regarded as normal.

Most striking of all is the complete absence of any microscopic evidence of the presence in ordinary commercial materials of oxides or silicates of iron, manganese or aluminum. So far as FeO, SiO_2, MnO and Al_2O_3 are concerned, the form in which they exist may well prove too small in quantity for microscopic identification.

AIK(4)

Testing "Brittle" Alloys

"Evaluation of the Plasticity of Brittle Cast Alloys." Ya. B. Fridman & Z. Ya. Kirenskaya. *Zavodskaya Laboratoriya*, Vol. 10, Jan. 1941, pp. 80-86. Experimental. In Russian.

Cast iron, magnesium cast alloy, and various aluminum cast alloys were tested by tension, torsion, compression, and indentation. It is suggested that as a new method in controlling the quality of brittle alloys measurements should be made of the diameter of the imprint at the formation of the first crack during indentation. This method is claimed to be more accurate in evaluating the plasticity of alloys than the determination of elongation. In addition, the method is simple and may be applied at various temperatures. The test specimens required are discs 0.120 or 0.280 in. high and 0.75 in. in diameter.

BZK (4)

Methods of Studying Alloy Systems

"The Equilibrium Diagram of the System Silver-Zinc." K. W. Andrews, H. E. Davies, W. Hume-Rothery & C. R. Oswin. *Proc. Roy. Soc.* [A], Vol. 177, Jan. 1941, pp. 149-167. Research.

In addition to describing a re-determination of the phase boundaries in the silver-zinc system, this paper makes a critical comparison of the accuracy of (a) heating and cooling curves, (b) microscopical observations on quenched specimens, and (c) X-ray measurements on annealed and quenched filings as methods of investigating various types of alloy systems. [*"Classical" as well as X-ray methods were used in the present work, and the result is likely to rank as one of the foundation stones of metallurgical literature.*—J.C.C.]

The liquidus curve determinations agree closely with those of Heycock & Neville; it is established that for this system the hypothesis of "whole number liquidus factors" does not apply.

The beta liquidus and soludus curves do not coincide at 50 atomic % Zn, as has been previously suggested, there being a freezing range of about 3½° C. The X-ray determinations by Owen & Edwards of the solidus boundaries of the beta phase are not confirmed, errors in the X-ray work being attributed to decomposition of the beta phase during quenching.

Generally speaking, the "classical" methods appear more reliable than high-temperature X-ray methods. The great source of error in X-ray methods is the uncertainty of the actual composition of the small mass of filings (microchemical methods of analysis being essential) and of their uniformity.

In this connection, it is emphasized that, contrary to the general belief, short annealing periods are not generally sufficient to eliminate inhomogeneity in filings.

JCC (4)

books

Metallurgy for Engineers

MODERN METALLURGY FOR ENGINEERS. *By Frank T. Sisco. Published by Pitman Publishing Corp., New York, 1941. Cloth, 6¼ x 9¼ in., 432 pages. Price $4.50.*

In the past few years, several books labeled "Engineering Metallurgy," "Metallurgy for Engineers," "Practical Metallurgy," or similar titles have appeared, each with the purpose of panning the available information down to nuggets and gold dust, for the benefit of those already well grounded but too busy to mine the new ore of current periodical publications. For the benefit of those not formally grounded in metallurgy, but forced, from their work as engineers, to deal with metallurgical matters, the books have to start from first principles, thus making them eligible for college text books, or at least for collateral reading.

These books, dealing with both ferrous and non-ferrous topics, have to cover a lot of ground; hence, only the highest spots can be hit by a one-volume work. Many of the same high spots are naturally picked out by each one of the various authors; the minor differences in contents reflect the opinions of the individual authors as to what items of secondary interest the type of reader he aims to reach will most profit by.

So the books differ in what is included and what is left out, in the emphasis put on each topic, and in the clarity of presentation and general readability.

Sisco's main topics are relation of structure to properties; significance of static and dynamic properties; heat treatment of steel; precipitation hardening; cast iron; carbon, low alloy and high alloy steels; tool and die steels, light alloys; copper-base alloys; other non-ferrous alloys; machinability, wear resistance and deep drawing properties; corrosion; and effect of temperature.

The emphasis placed on the topics and their sub-divisions is good. Omissions there have to be in any such book, and omissions there are, but nothing worth quarreling about. In other words, the selection is excellent.

It is in the method of presentation and its readability that the book scores heavily. The reviewer has glanced through a lot of such books in eleven years of reviewing, has carefully read certain parts of most of them, and has less carefully read those parts that are repetition of oft-stated truths that have seldom been as well discussed as they were in the old books by Howe and by Sauveur, but this is one of the few in which he has read nearly all of it, at one sitting, and with enjoyment and appreciation. When a book that one opens with the plan of just glancing through it, can make one actually read it when he isn't hunting for any specific information, it has something.

After years of editing the Alloys of Iron Monographs, coldly formal in tone and necessarily with abtruse, high-brow sections, it must have been a relief for Sisco to use informal phraseology where it best drives home a truth, and to omit high-brow material of doubtful utility to the probable readers of a work with this title.

It's a good title and the book fits the title.

—H. W. GILLETT

Hot Tinning

HOT TINNING. *By C. E. Homer. Published by Tin Research Institute (Pub. No. 102), England (In the United States: Battelle Memorial Institute, Columbus, O.) 1941. Paper, 8¼ x 10½ in., 28 pages. Price: No charge to those interested.*

This booklet gives complete, workable information on the hot tinning of steel, alloy steels, cast iron, copper and copper alloys. In particular, sections dealing with the preparatory steps of degreasing, pickling, and fluxing are informative and practical. The tinning operation itself is adequately covered to include the handling of articles of various sizes and shapes, as well as the different methods of tinning and maintenance of good working conditions.

Other important sections include the retinning of milk cans and other articles, the removal of iron and copper from the tinning bath, terne coating, and tinning articles on the inner surface only by wiping methods. A list of 30 references, 9 illustrations and several tabulations are included.

—B. W. GONSER

Aircraft Welding

AIRPLANE WELDING AND MATERIALS. *By J. B. Johnson. Published by Goodheart-Willcox Co., Inc., Chicago, 1941. Flexible binding, 5½ x 8 in., 409 pages. Price $3.50.*

This is a very practical handbook, for the information of welders and inspectors of welds on aircraft. The metallurgy involved, particularly that of S.A.E. X 4130 steel, and of aluminum and nickel alloys, is very briefly, but accurately, discussed.

Modern equipment and modern methods for welding, some of them too new to have had adequate discussion in older handbooks, receive attention. On the metallurgical side, grain size, hardenability and the like are brought to the practical man's attention as of equal importance with composition.

As would be expected from Johnson's long experience in the field, the book is accurate and authoritative. The surprising thing is that a man who knows so much, can say it so well in so few words.

—H. W. GILLETT

Gears

GEARS AND GEAR CUTTING. *Edited by F. J. Camm. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y., 1941. Cloth, 5¾ x 8¾ in., 144 pages. Price $2.00.*

Mr. Camm presents a brief and thorough treatise dealing with methods of cutting all types of gears, including spur gears, helical gears, worm gears, bevel gears, spiral and screw gears.

The book is divided into twelve chapters covering such subjects as types of gears, methods of cutting, gear generation, gear-wheel forms, gear trains, methods of mounting, measuring of gears, cutting tools, load capacity of gears. efficiency of gears, and useful formulas for gears.

It is well illustrated with photographs of various types of gears, cutters and machine tools. The numerous diagrams, sketches and formulas for engineering design and inspection add greatly to its value. The text is clear, concise and to the point.

This volume is a very useful reference handbook for the designer, inspector and manufacturer of gears.

—N. E. WOLDMAN

Other New Books

FORMING ALUMINUM. *Published by Aluminum Co. of America, Pittsburgh, 1941. Paper, spiral-bound, 5½ x 8¼ in., 53 pages. No charge.* An unusually valuable manual covering the blanking, piercing, drawing, spinning, embossing, etc., of sheet aluminum and its alloys.

trends

By Edwin F. Cone, Editor

Aluminum

A statement recently released by the Aluminum Co. of America is to the effect that during 1939 the country's output of aluminum was 327,000,000 lbs. "Domestic production at present (June) is at the rate of nearly 600,000,000 lbs. annually, and by July, 1942, will reach 825,000,000 lbs. a year." By July, 1942, the company's output will be more than double the production built up over a half century; it will then amount to more than 720,000,000 lbs. It is further stated that the "forging capacity in the plants of the Aluminum company has been increased approximately 175 per cent; extruded shapes capacity, sheet capacity, and tubing capacity have in each case been more than doubled, while wire, rod and bar capacity is up 130 per cent, and sand casting capacity is now approximately 200 per cent more than it was at the start of the war in September, 1939."

British Razor Blades

One of the rather novel trends, caused by the war, and one not naturally expected, is the huge export market for razor blades developed by British makers, a market largely in the hands of Germans before the war. We are informed by Cricklewood Razor Blades, Ltd., of Humber Road N. W., London, England, that 33 British manufacturers exported last year an average of 1,125,000 razor blades a day. "The enormous total of 456,250,000 blades would, end to end, run to 12,600 miles and the value to £700,000 a year."

One reason for this development is stated to be the fact that these producers have stopped making the blade holed to fit only a particular make of safety razor; most of the blades are 3-hole universal type fitting any razor made.

Electric Steel—"Bottleneck"?

In a report to the stockholders of the Republic Steel Corp., T. M. Girdler, chairman, and R. J. Wysor, president, state that electric furnace steel has been one of the potential defense bottlenecks and Republic has been expanding rapidly in this department. At the close of 1939 Republic's electric steel capacity was 146,000 tons per yr., and when two new furnaces just ordered are installed it will reach 725,000 tons. Republic's electric steel goes into armor plate, anti-friction bearings, alloys for aircraft and gun linings, etc.

Electric Furnaces in Steel Foundries

In the April 1940 issue of METALS AND ALLOYS, page 99, there was an article—"'Steel Foundry Progress in Melting and Heat Treating." It was based on an analysis of the "Directory of Steel Foundries in the United States and Canada—1940," published by the Steel Founders' Society of America.

That analysis showed 319 electric melting furnaces of all types in the industry in 1939. A similar analysis of the 1941 edition of the Directory shows that there are 329 furnaces, a gain of 20 in 1940. This expansion will probably be considerably larger this year.

Induction Furnaces: The 1941 analysis referred to shows a distinct gain in the installation of high-frequency induction furnaces. There were 23 in 1939—by 1940 this had expanded to 30, according to the Directory.

Distribution of Finished Steel

Reversed trends in the distribution of finished steel in 1940 as compared with 1939 are shown by a survey and analysis by the American Iron and Steel Institute, its first attempt of this kind. Most of these are the result of the dislocation of industry by the War. Leading all the outlets last year are exports which made up 17.7 per cent of the total—in 1939 these stood seventh at 6.53 per cent. Among domestic consumers the automobile stood first last year at 15.7 per cent—in 1939 this industry stood at the top at 18.10 per cent, including exports. This is the ninth consecutive year that it has held first position among domestic users. The second largest last year among domestic consumers was building and construction at 10.8 per cent, reflecting the building of plants and cantonments—in 1939 this industry's position was third. Ranking third domestically was the railroad industry last year at 10.8 per cent—it stood second in 1939. Of interest is the role of warehouse distributors—14.6 per cent in 1940, third among all consuming lines and a new record in tonnage.

Defense Jobs

The U. S. Steel Corp.'s subsidiaries are now training 15,000 employees for skilled defense jobs—described as "one of the largest programs in the history of American industry." This is a highly important trend and will do much to help in the supply of skilled workers in the Defense Program. The training is of two kinds—to fit a man for the next higher job in regular mill operations, or to equip him for special defense operation.

Small Additions of the Less Common Metals

The addition of small percentages of certain unusual elements to steel expands. We have had lead for "Ledloy," titanium and columbium for stabilizing stainless steel, selenium in free machining stainless and so on. Now comes another rather startling development—bismuth in stainless steel, bestowing thereon free-machining qualities and welding properties with other advantages. It was announced for the first time at the A.S.T.M. convention in Chicago, June 26.

Analogous to this are the additions to certain non-ferrous metals or alloys, conspicuous among these being beryllium in beryllium-copper.

This trend is expanding rapidly and the results, in some cases rather astounding to the layman, are highly beneficial. We may look for still others.

(Additional "Trends" on page 260)

trends

By Edwin F. Cone, Editor

Low Sulphur in Pig Iron

More than one large steel producer is seriously considering the installation of special apparatus for desulphurizing the molten pig iron from the blast furnaces. It is claimed that a pig iron running 0.04 to 0.06 per cent can be reduced quickly to 0.03 per cent or less by the use of soda ash in some form. This is said to make it possible to modify the blast furnace practice which insures a pig iron low in sulphur. Hence the speed-up of the furnaces is increased by a substantial percentage.

Steel Ingots

The Defense and Aid - to - the - Democracies Program is boosting the steel ingot production to record high totals. The output for the first half of 1941 at 40,912,000 net tons is 40 per cent above the same period in 1940.

This indicates a total for the year of approximately 85,000,000 tons—the 1940 total was 66,982,686 tons.

Saving Defense-Needed Metals

Typical of what is being done throughout the automobile industry in the saving of metals needed for defense is the program of one large producer as reported by a member of the metallurgical staff. In its 1940 models this company used ½ lb. Mg per car; now it uses only 0.006 lb. per car. Nickel has been reduced from 2.07 lbs. to 0.32 lbs. per car. Aluminum was used at the rate of 4.13 lbs. per car, including 1.06 lbs. of primary grade; all the aluminum now used is secondary grade. As to zinc, formerly used at 35 lbs. per car, this has now been reduced to 23.1 lbs. with further savings indicated.

What Next in Capacity!

There has been talk in some Government circles of a necessary expansion in the American steel industry by 1942 of surprising proportions—up to 120,000,000 tons of ingots and 25 more blast furnaces! Rather fantastic, especially when the material necessary to provide such an expansion would be almost impossible to procure. It is difficult even now to secure the raw materials for operating present equipment.

Die Castings of Lead

A greater amount of die castings of antimonial lead is now being made than ever before. This is due to the fact that zinc is not now available in the quantities formerly used in this industry, because of the demands of the Defense Program. Though lead is 1.6 times as heavy as zinc it is being incorporated as die castings for wind shield wipers, electric fan bases and so on. While there are certain manifest objections to lead as compared with zinc as a base for such castings, it is a case of take the lead—or else.

While there is not much likelihood of a permanent stringency in lead, the antimony required for these ersatz die castings is enough to unbalance the antimony situation, which has already been made precarious through the large increase in use of Sb_2O_3 as pigment and opacifier.

More Aluminum Fabricated Products

At its plant in Los Angeles, Cal., the Aluminum Co. of America has increased its equipment to the extent that the capacity for sand and permanent-mold castings all have been increased 40 per cent and the capacity for forgings 350 per cent. The new extrusion plant will soon be turning out extruded shapes at the rate of 1,019,000 lbs. per month and the new rivet plant at the rate of 70,000 lbs. a month.

By March, 1942, the forging capacity of the company's Vernon works, a section of Los Angeles, will have been increased an additional 50,000 lbs. a month.

The Lafayette (Ind.) works of the company is a fairly new plant. By December this year, the extruded shape capacity will have been expanded to 4,256,000 lbs. or six times that of 1939, and the tubing capacity will have reached 1,034,000 lbs. a month or nine times that of 1939. The latter, however, by April, 1942, will have been expanded to 1,348,000 lbs. per month or 11 times that of 1939—all this as per an announcement by the company.

Electric Steel

As reported in our June issue, page 729, the total output of electric steel in 1940 reached a new high at 1,700,006 net tons. This was 2.54 per cent of the total steel output, also a new record. While the electric steel output this year will no doubt surpass that for 1940 at over 2,000,000 tons, it is not improbable that its percentage of the total output will be less than in 1940 because of the greater increase in the production of open-hearth and Bessemer steel due to the Defense program.

Substitute for Tin in Solder—Silver

According to a report of a committee of the National Academy of Science to the O.P.M. silver is suggested as a substitute for tin in solder. All-out replacement of tin in solder can be effected by the use of 66,000,000 oz. annually, and at about the same cost. Two to 5 lbs. of Ag may replace 40 to 50 lbs. of Sn. The search for substitutes is bringing results!

By all-out substitution in every possible line, said the committee, which would require construction of much special equipment and some temporary hardship, it is believed that at least 75 per cent of the tin ordinarily used could be replaced. This means that domestic smelting of Bolivian ores would supply most of the irreducible minimum.

(Additional "Trends" on page 258)

Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION · FABRICATION · TREATMENT · APPLICATION

SEPTEMBER 1941